THE MARCH OF TIME

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PUBLICATION

The March of Time

by

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PREFACE

My object in this little book has been to help teachers in one of their chief tasks, that of awakening in their pupils an interest in the scientific developments going on in the world. Having failed to acquire such an interest while at school myself, I have tried to sketch some of the ideas which I have found fascinating since then, in the kind of form in which I think they might have struck me had I met with them earlier. I have left out what seems to me of merely mechanical interest, such as the well-worn stories of Stephenson and his steam-engine, and concentrated on two attempts. to show the Indian schoolboy the supreme significance of science for the future of his own country, and to touch his imagination by hinting at some of the marvels of the latest researches, even though these may be too complex to be fully grasped by the reader — or by the writer. Having myself no more knowledge than can be picked up through general reading, and talk with better-informed people, I can only hope that I have not fallen into any seriously misleading statements.

The primary purpose of the book, of course, is to teach English, in as painless a manner as possible. The obligation to keep the language on a fairly elementary plane has often made it necessary to suggest rather than to explain. I have tried to make the reader's path smoother by adopting a conversational form, and giving each little dialogue a setting familiar to the Indian schoolboy.

V. G. K.

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I. ELECTRICITY

Gopal Krishan leaned back in his chair, just under the ceiling fan, and sighed happily.

'How wonderful it is to live in a city!' he exclaimed. 'I wish I could stay here all through the hot weather, instead of going back to the village!'

'Why, what is so wonderful about it?' asked his uncle, who had been living in Lahore for many years as a lawyer, and thought that the city needed a great deal of improvement.

'Life here is so comfortable,' replied his nephew. 'This fan, for instance; when I sit just underneath it like this, I feel as if a stream of cool water was pouring down on me, all the time. It is as good as being in the hills!'

'But you have punkahs in the village, haven't you?'

'What use are they! You have to get a little boy to swing them all the time, and he keeps falling asleep or running away. He only gets an anna a day for it, so he is not likely to work very hard. And you know how hot it is round Multan at this time of the year.'

'Yes, I do!' said his uncle. He looked up at the fan. 'It's rather strange, by the way, that a fan makes you feel cool, because as a matter of fact it makes the air slightly warmer.'

'Does it ?'

'Two things rubbed together always produce heat, and the blades of the fan are rubbing against the air. But the breeze it makes dries the perspiration on your body, and your skin gives up some heat in helping it.'

'And then you have this fine radio-set,' went on Gopal, looking across the room at the radio, which was playing softly some Indian music. 'We can't have one at home, because we have no electricity.'

'Electricity ! Yes, that is the great thing ; most of the comfort we have in a city like this is due to electricity, besides the cinemas, which are our chief amusement. Have you looked at my new refrigerator ?'

'No, but I have drunk some splendid cold water from it. May I have some more, uncle ? It makes me thirsty just to think of it. We never get such cold water at home in summer.'

'Of course ! Come, I will show you how it works, though I don't know very much about it myself. Let me close the windows over there ; I think this wind is going to bring a dust-storm, and we don't want the house to get full of dust.'

He closed the windows, and led Gopal into the next room, where the refrigerator stood in the corner, like a cupboard of shining white metal.

As they approached it, there was a sudden click, and the machine began to make a purring noise. Gopal jumped.

‘ Has something gone wrong with it ? ’ he asked. His uncle laughed.

‘Oh, no. It has an electric motor inside, which starts automatically when the temperature inside rises above the level you want. You fix that by moving the switch here,’ he added, pulling open the door. As he did so, an electric bulb inside began to shine. ‘ For instance, if we want to make some ice, we fix the temperature at the lowest point, below freezing point. Look.’

He opened a kind of metal drawer in the middle of the refrigerator, and drew out an oblong basin divided into a dozen small squares. Each of these contained a small cube of ice.

‘ You pour water into this basin, and in half an hour it is frozen, and you can take out as many pieces of ice as you need. Take one for yourself, Gopal, and I’ll pour you some lemonade. Poke it out with this knife.’

‘ Strange, that electricity can cool things,’ remarked Gopal, as he removed a piece of ice. ‘ When I was here in winter, you had an electric heater working here ! ’

‘ Yes, electricity can do quite opposite things. It depends on how you use it. A refrigerator is much more complicated than a heater,or a cooking-oven. In America most of the cooking is done in electric ovens ; so the kitchens can be kept perfectly clean.'

Gopal drank his lemonade thirstily, and held out his glass for more.

' You are really living in Heaven, uncle ! '

' It does taste well, doesn't it ? Besides, you know, it keeps you much healthier, if you have one of these machines, because you can keep milk here, or any sort of food that goes bad quickly in hot weather, like butter or cheese ; and the coolness keeps it fresh. There would not be many diseases among people if everyone could do this.'

' Why don't they ? '

' My dear boy, this machine cost me a thousand rupees. I bought it this year after winning a big law case, over an estate, in which I earned a good deal of money. But how many people in Lahore can spend a thousand rupees, do you think ? '

' Not many, I suppose.'

' No, unluckily there are very few refrigerators yet in India. This one came from America, though we should be able to make plenty of them in India before long.'

They had just got back to the sitting-room again and sat down, when there was a sudden loud rushing of wind outside---the dust-storm was quite strong by now. A few moments later the lights went out, and the radio became silent.

'What has happened!' cried Gopal.

'The current has failed,' said his uncle---'that's clear enough; but I wonder if it is only due to a fuse-wire in the house having burned out. If so, we can repair it. Let me see---' he got up and felt his way towards the window. 'No; the lights have gone out in the other houses as well.'

'What does that mean?'

'It means that the main wire bringing electricity into this district has failed. That often happens on this side of the town, when there are storms: the wire is blown down, or a tree is blown down and falls on the wire.'

'What are we to do, then?'

'Wait until the Electric Company sends men to repair the wire.'

'Where is the company?---I mean, where does the electricity come from?'

'Lahore has two sources of supply,' explained his uncle, wiping his forehead, for it was already hot in the room with the fan not working. 'One is from Mandi, in the hills; a swift river there is used to turn wheels, and the wheels are connected with a dynamo ---the machine that turns other kinds of energy into electricity. We call this hydro-electricity, which means 'made by water'. The other supply is produced in Lahore itself, with machines driven by coal.

A servant came in with a bundle of candles, and lit two or three of them.

‘ Now, Gopal,’ remarked his uncle, ‘ what do you think of the blessings of city life ? We have become almost slaves to electricity, and without it we fall back in a moment from the twentieth century to the Middle Ages ! No cool breeze, no music, no ice now ! ’

‘ What would happen if all electricity disappeared ? ’

‘ That is not likely to happen ; according to modern science, everything in the world is made of electricity, or something very like it. But it does happen sometimes that a whole city loses the use of electricity for a long time. Suppose there is a war going on, and no coal can be brought to feed the power-stations where electricity is produced. Then life becomes very difficult.’

‘ Well, perhaps we are really better off in the village, after all ! ’ said Gopal thoughtfully.

‘ In bigger cities than Lahore, electricity plays a still greater part. Bombay and Calcutta, and nearly all Western cities, use tramways for transport. Have you ever seen them ? ’

‘ Yes, in Delhi.’

‘ Oh, of course, they have them there too. You must have noticed that each tram has a long pole on top, touching a big wire hung along the road overhead. The electricity comes along the wire from the power-station, and down the pole into the motor of the tram-car.’

‘ And the electric trains in Bombay run in the same way ? ’

‘ Yes, it’s the same system. It is better than using ordinary railway engines in a crowded area, because you don’t get any clouds of dirty smoke pouring over the houses. By the way, have you heard of the Western underground railways ? ’

‘ I saw some pictures in a magazine, of a big new one in Moscow.’

‘ You see, a city like London is too crowded for many railway lines to be laid through it ; but there are seven million people in London ---ten times as many as in Lahore---and they all want to travel about ; to their work or to the shops. If they all went in trams and lorries, the roads would be so full of traffic that no one would be able to move. So they have to dig deep tunnels under the ground, and the local railways run through them. They have to be electric trains, because steam-engines would fill the tunnels with smoke and choke everyone.’

‘ Were they there when you were in London, uncle ? ’

‘ Yes,---long before I began studying Law ! But you know, what surprised me in the underground even more than the trains themselves, was the electric staircases.’

‘ Staircases ! ’

‘ Yes, stairs that move slowly up and down like the buckets on a Persian wheel, but slanting, like an ordinary staircase. You stand on the lowest step, and it carries you up to the top. That saves people from wasting energy in climbing up from the tunnel-stations to the street. Why should energy be wasted ? Think of the people working in the New York sky-scrapers. You must have seen pictures of those buildings.'

'Yes, often. They seem to be as high as hills.'

'They are. Some are over a thousand feet high. If you were working in an office near the top, would you like to climb up so many hundreds of steps every morning ? '

'No.'

'No, of course not ; so they all go up and come down in lifts---big boxes carrying a dozen people, which run up and down vertical shafts like chimneys. Those lifts are worked by electricity. If they stopped working, everyone would come to his work late---and in a city like New York that would mean a loss of crores of rupees every week. Or if there was no electricity for the telephones and telegrams, business would be very hard to carry on. Besides, there are many industrial processes which use electricity, such as electroplating for covering a piece of metal with a very thin coat of another metal. What we call a tin can is really iron covered with a thin layer of tin. And then electrical machines are used in hospitals for certain kinds of diseases. In America, by the way, they use electricity for just the opposite purpose—executing criminals.'

'But, after all, uncle, what *is* electricity? What did you mean by saying that everything was made of it?'

His uncle sat thoughtfully for a minute, staring through the window into the whirling dust clouds, and wiping the perspiration off his face.

'None could really answer that question,' he replied at length, 'and my business is Law, not Science. I only know a little about it by reading a few simple scientific books, as every educated man should. All we can say is that electricity is an energy, or force, which can travel through most kinds of matter, and even through empty space---space without any air. But the whole world, which looks so solid, is really not at all solid when you examine it scientifically. Your body, for instance, is practically empty; it consists of very tiny atoms, floating in emptiness. It is impossible to say whether they are particles of matter, or energy, and nearly all kinds of energy seem to be connected with electricity. Take magnetism, for instance---you must have played with magnets?'

'Yes, I like holding one under a sheet of paper with iron filings on it, and seeing how they move about and form themselves into a pattern.'

'You probably know that if you rub a bit of dry brown paper against your sleeve, it becomes electrified, and it will hang to your sleeve by itself. On the same principle, huge electrical machines have been made to do the work of cranes; they lift great metal weights off the ground by magnetic energy. What electricity is, nobody can say. But I can tell you this: your own brain is giving out electrical currents all the time, which can be measured and recorded. The harder you are thinking, the stronger the currents. People have even made doors with electrical devices on them, which open when you look at them. You have only to stand in front of the door, and the electric waves from your brain will make it open.'

'Wonderful, uncle! Where can I go to see all these things?'

'At present you would have to go to Europe or America. But there is no reason why we should not have them all in India before long. The most valuable thing India possesses is the Himalayas, because they are full of streams and waterfalls which could be used to produce hydro-electric power. This power could be carried everywhere by a network of overhead wires---even into the villages. You could have water pumped up out of your wells by electric pumps. And what is even better, the same power could be used to cool the villages. Each house could have one room fitted up like a big refrigerator, and the temperature there would always be the same, however hot it might be outside. Think what a difference that would make to the Punjab ! '

' Oh, uncle ! Life would be worth living all the year round, if we would do that ! '

There was a sudden click from the ceiling, and the fan began to turn again : the lights came on, and the radio began to play music.

Gopal ran back to his favourite armchair under the fan, and stretched himself out blissfully.

' Good ! ' exclaimed his uncle. ' Now we are back in the twentieth century ! '

II. FARMING---OLD AND NEW

The boys were out walking one evening, in the field, when they saw a stranger sitting under the shade of a big tree, near a well.

His clothes showed that he was a townsman, and there were a number of cardboard boxes and brown paper parcels scattered round him on the ground. A cycle was leaning against the tree.

His back was turned towards them, and as they came closer to him, wondering who he was, he began to sing. He had a fine voice, and the song sounded very pretty in the calm evening air. They gathered round him and sat down to listen.

The stranger, who was a young man, with a good-humoured face, seemed a little surprised at the sight of them, but he went on singing until he came to the end of his song.

'Well, well!' he remarked, looking round at his audience. 'You boys seem to be fond of music!'

'Oh, yes!'

'I am very glad then; but I was really hoping that some different people would come to listen.'

'Who?'

'The people of the village. You boys don't live there, do you?'

'No, we live in the town, two miles away. We are just taking a walk,' said Jagjit.

'But, where are the villagers? I don't see any of them.'

'They have gone to the next village over there, where a *mela* is being held. We wanted to go too, but our parents would not allow us, because tomorrow at school there is an examination, so we should go to bed early to-night.'

The stranger looked disappointed.

'In that case, there is no work for me to do here,' he said, 'and I had better move on.' He began collecting his parcels.

'But what work did you want to do?' asked Prem Nath. 'Why did you want to see the people here?'

'Or is it a secret?' added Jagjit.

'Oh, no secret at all. I belong to the Department of Agriculture. I am one of the Touring Staff.'

'What does that mean?' enquired Manjit, who was always the bottom boy of his class.

'Don't you know? It means that I am one of those who go round the villages to persuade the farmers to take up new methods of agriculture, which the Department has discovered by carrying on experiments.'

The boys thought this over.

'But why were you singing here, instead of going to the houses?' asked Manjit.

'The fact is,' explained the stranger, 'it is not always very easy to persuade the farmers in this district to listen to new ideas on Agriculture. You boys, of course, have the benefit of education, so you can see the importance of my work very easily, can't you ?'

'Yes, of course,' replied Prem Nath---rather to the surprise of Manjit, who had been about to say 'No'.

'The most important work in the world !' cried the stranger, with enthusiasm. 'But these poor people---They don't understand. Often I go to a village, and instead of welcoming me as their best friend, they just laugh at what I say ! Can you believe it ?'

'Yes,' said Manjit, thinking he was saying the right thing this time.

'So what do I do ?' went on the stranger. 'What do I have to do ? Sing ! Yes, sing about love, instead of talking about manure ! It's disgraceful. But there it is. I find that if I come quietly and begin singing under a tree, people come up to listen, and after I have sung myself hoarse, I may be able to get them to listen to some common sense. Sometimes I do conjuring tricks instead.'

'Well, you can tell *us* about your ideas, if you like,' said Jagjit politely. Manjit looked at him crossly, and wished he had asked for some conjuring tricks instead.

'Why not !' exclaimed the stranger. 'After all, *you* are going to be the educated young men who will have to save this country, and my work must be much more interesting to you than what you learn at school. History ? Rubbish ! Algebra ? Nonsense ! Agriculture, my boys,---that is what you should know all about ! '

Manjit, who agreed with at least part of what the stranger had said, was just going to ask him to go on when Prem Nath---who always used to interrupt him in the class when the teacher asked a question---said :

' Nowadays everybody is talking about new industries. Doesn't India need industries most of all ? '

The stranger leaned towards him and asked, tapping him on the shoulder---

' Tell me, what is the population of this country ? '

Prem Nath answered promptly---

' Forty crores.'

' Right ! ' said the stranger. ' And what was the population ten years ago---I mean, ten years before it was last counted ? '

Manjit was very pleased to see that even Prem Nath could not answer this.

' Thirty five crores ! ' exclaimed the stranger. ' In other words, an increase of five million every year---four hundred thousand every month---eleven thousand every day ---four hundred and fifty every hour ! '

Manjit who imagined that he was working out these figures in his head, was astonished at his speed.

'Yes, my boys!' went on the stranger warmly. 'Every day this poor country has to feed eleven thousand people more than the day before! Think of *that*, and then ask yourselves whether anything can be more important than agriculture!'

He seemed so excited about the matter that even Manjit began to feel impressed.

'We have several experimental stations in Northern India,' went on the stranger; 'the biggest of them is at Lyallpur. You should all go there one day and look round it carefully. Crops, soils, insects---they are all being studied. Take sugar-cane. Farmers want their fields to give a big crop, of a high quality. Formerly and in some parts still they were using a type of cane, which only gave a small harvest per acre. Now we have found types which produce far more.'

'Then why don't all the farmers use it?' asked Jagjit.

'Ignorance, my friend---dislike of everything new. It isn't their fault altogether; there ought to be more men doing my work---going round to each village regularly. Or take grain crops, which are even more important. There are hundreds and hundreds of different kinds of wheat and rice. Government have sent experts all over the world to find them. Some are bad, others are much better; besides, some have special qualities---of being able to grow in a hot climate, or a cold climate, or in a certain kind of soil, or of being able to resist diseases. Our business is to choose the best kind for each particular part of the country, and persuade the farmers to grow that ; and we get new kinds, by 'crossing' two old ones---marrying them together, so to speak. 'Look' ---he pulled open some of his boxes---' I have some of the best kinds of seed here. But still, in all India only about half the farmers are using our new seeds. In this very district they are growing a wretched kind of wheat---and yet I have to sit under a tree and sing songs to get them to listen to me ! '

He stopped, out of breath with his rapid talking, but before Manjit could think of a way of bringing the subject round to conjuring tricks, he started off again, with a fresh burst of enthusiasm.

' Look at the potato, my friend ! ' (Manjit looked hard, but could not see one anywhere). ' To me, a fine potato is the most beautiful thing in the world ! Anyway, it's one of the richest kinds of food in the world, and we don't grow enough of it in this country. Have you ever wondered how many different valuable substances there are in a potato ? '

The boys shook their heads, in some surprise.

' About twenty ! Of course, four-fifths of the weight of a potato is just water, and most of the other fifth is starch. But besides those, it contains three kinds of sugar, nitrogen, acids, iron, sulphur, and half a dozen other minerals, and vitamins. In fact, a man who ate a good many potatoes and drank a couple of glasses of milk every day, would need scarcely any other food. Have you seen potatoes growing in the hills ?'

'Yes !' said Manjit, before any one else could speak. He went to the hills every year, so he thought he must have seen potatoes.

'Ah !' returned the stranger, with great interest. 'Where, exactly ?'.

Manjit blushed and Prem Nath remarked unkindly---'Manjit couldn't tell a potato-field from a rice-field !'

'Go to Simla !' said the stranger. 'See the Potatoes growing on our experimental farm there, thousands of kinds, from all over the world. A beautiful sight !' He closed his eyes for a moment, with a happy smile on his face. 'Potatoes grow well in the hills because that is where they first grew. Not in our mountains, but in the Andes—.'

'In the east of South America,' interrupted Prem Nath (who in Manjit's opinion was always trying to show how clever he was).

'Exactly,' said the stranger, patting Prem Nath on the shoulder. 'In the Andes, potatoes have been grown and eaten for at least 2,000 years ; and they were so valuable to the primitive people living up there that they seem to have been worshipped. In ancient times, men seem to have cut their own lips and noses off, in honour of their Potato-god !'

'What!' exclaimed the boys all together. 'Why?'

'Oh, they probably had the idea that their sacrifice would make heaven kind to them, and their potatoes would grow better. But now, luckily, we have better methods, eh!---otherwise my Department might expect me to cut *my* nose off for the sake of the crops!' He laughed heartily.

'But potatoes grow in the plains as well,' said Jagjit.

'Oh, yes. And the great quality of the potato is that it can keep more people alive, on a fixed area of land, than a crop like wheat can. In Great Britain they get about 200 maunds of potatoes from each acre, which means that about four thousand people could live for a year on one square mile. Look here!' He pulled out a note-book hastily from one of his bags. 'I'll show you a few more figures, that will absolutely amaze you!'

Manjit yawned; he was beginning to feel sleepy, but the other boys eagerly moved up to the stranger's side to see what he was writing.

'Look,' the stranger went on, scribbling rapidly. 'Four thousand people per square mile. The average in the Punjab at present is only about 750 people on every cultivated square mile, and yet we are already talking of over-population. Now in Great Britain, working with every scientific method, they have been able to grow fifty tons of potatoes on one acre. That means that one square mile could feed twenty-five thousand people. Each man would eat the potatoes from a tiny patch of eleven yards square, and be well fed!'

'I don't want to eat anything except potatoes all my life,' said Manjit, who felt he had heard quite enough about them.

'Of course you do not, my friend,' returned the stranger. 'In the first place, we need milk, so we must have plenty of land with good rich grass to feed our cows. Secondly, we want variety, to make life more pleasant---wheat and such crops, fruits, vegetables. Besides, it is dangerous to rely on a single crop. In Ireland for a hundred years there were eight million people, living chiefly on potatoes. Then a disease suddenly attacked the potatoes and destroyed the harvest. A million people died of starvation, and many others had to emigrate to America. There are less than four million living in Ireland now.'

'But does all this mean,' asked Jagjit, 'that everybody in India could be well fed?'

'Certainly! Why not! But only if we adopt all the scientific ideas they have got in the West, and invent some new ones of our own. At present our average production of food per acre is very small, compared with most foreign countries. Machinery, for instance,—in Russia, on the huge co-operative farms, they use motor-tractors to pull the ploughs, and the harvesting machines. And in Russia they even sow their seeds by scattering

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them from an aeroplane, when the sowing has to be done quickly. They also use aeroplanes to drop chemicals over the crops, and destroy pests like the locusts that come to India every year over the sea from Arabia and do so much damage.'

'Can locusts really fly so far?' asked Jagjit.

'Oh, yes. Right over the sea. Sometimes millions of them settle down on a poor little sailing ship, to take a rest, and their weight will actually sink the ship. The Indian Government has experts all over Baluchistan, where the locusts stop to lay their eggs, watching them and trying to destroy them. But there are many other insect-pests which damage crops, and our farmers have not learned the scientific methods of checking them.'

The stranger began to fasten up his parcels.

'Well, I must be getting on,' he said. 'Just have a look at my cycle, will you? I hope the tyres are all right. I have punctures nearly every day on these horrible paths. By the way, let me tell you one other way of producing food: we can grow vegetables now without any land at all!'

'How? In the air?'

'No, in big glass jars containing chemical solutions. In that way we can produce bigger vegetables than even in the best soil. This method is too expensive now, but in a few years—ah, my friends, in the next few years you will see science performing more and more miracles!'

He jumped up, and began fastening his parcels on the back of his cycle.

'Just one other thing I may tell you,' he said, as if he could not bear to stop talking about his favourite subject—'about storing food. Many kinds of food, like vegetables, decay quickly. But if you crush all the water out of them, all the useful food remains, in a small bulk. You can easily preserve it, and send it long distances. This method was used a great deal in the last War, when food had to be sent by air to troops in the middle of the jungle or on islands. But those ancient people in the Andes were doing it with potatoes long ago.'

'Sing us another song before you go!'

'Oh! So you also are more interested in music than in science! Poor science! Oh, well,' —the stranger smiled good-humouredly and leaned his cycle against the tree again. 'I'll sing you one more song. Only remember, my friends—India has only two choices: science or starvation!'

III. INVENTIONS OF TODAY AND TOMORROW

Salim had a cousin who had taken a very good degree in Physics in the Panjab University. After he left college he had been given a Government scholarship to go to America; and had studied for two years at the famous Institute of Technology at Massachusetts. Now he had come home and become a teacher in the University.

Salim had come to Lahore to welcome him on his arrival, and a few days later they went together to see the newly-built laboratory where Dr. Mahmud Ali was to work.

Salim wandered about the spotless, shining room for a long time, staring at the rows of instruments and test-tubes. At last he sat down on a bench and began peering into a microscope. He could see nothing but a dark blur, until his cousin came and turned some screws at the side of the tube. Then suddenly a bright round picture came into view, with a sort of pipe-line running across it, darker in the middle than along the sides.

'What do you think you are looking at ?' asked Mahmud.

'I don't know—a caterpillar ?'

'No ! It's a hair. Do you know how a microscope works ? No ? Well, you know what a magnifying-glass is, don't you ?'

'Yes, a piece of glass thicker at the middle than round the edges.'

'That's right, and it makes things look bigger because the rays of light passing through it are bent out of their course. A microscope is just two sets of glasses, or lenses, of that sort, one at each end of a tube. It can make a thing look two thousand times bigger than it really is. And a telescope is the same kind of thing, only much bigger, and made for looking at things far away. Have you ever seen one ?'

'No, have you got one here ?'

'There is one in the Lahore Observatory---you know, the place where they study the stars. Some day I must take you to see it.'

'What long names all these things have ! How can you ever remember them ?'

'You just have to get used to them. These scientific words in English are nearly all taken from Greek, in the same way as we use Arabic words in Urdu. You may not realize it, Salim, but you already know quite a lot of Greek words.'

'What words ?'

'You know *telegraph* and *telephone*, for instance. '*Telos*' is the Greek for 'distant.' *Telephone* means a sound from a far-off distance. And such words are being used all over the world now.'

'What does 'microscope' mean ?'

'*Micros* means 'small,' and *scope* means 'seeing.' It helps you to see small things. Now tell me what 'microphone' means.'

'A small sound,' replied Salim, after thinking for a moment.

'Yes------that is the instrument for making small sounds louder, that people use when they are making a speech to a big crowd of people.'

'You mean a loud-speaker ?'

'Yes, the same thing. So you see how easy it is to learn these words, if you just take the trouble to understand them. And everyone ought to learn about science, Salim. The world is full of wonderful inventions. Every day there are more and more of them. In fact, what I have just been learning in America will be half out of date before the end of the year. If you live long enough you will see some amazing things.'

'Long enough ? How long ?'

'Oh------five years, ten years twenty.'

'I can live for another sixty years, can't I ? Grandfather was nearly eighty when he died !'

'You can, if you take care of your health, and if there is not another big war. If there is, not many people may live through it anywhere. But I should like to live for a hundred more years at least ; there will be so many new things to learn all the time.'

Salim, who was already looking forward to leaving school, was not sure whether he wanted to go on learning things for another hundred years.

‘For instance,’ Mahmud went on, ‘this microscope here’---he patted it as if it were a pet dog---‘is already out of date. Some of the things we would like to see are hundreds of times smaller than the smallest things it can show us. In fact, we should never be able to see them by ordinary light.’

‘Why not ’

‘I don’t know whether I can explain it to you. How much do you know about light Do you know how fast it moves ?’

‘At one hundred and eighty-six thousand miles per second,’ answered Salim promptly.

‘Good—but could you prove it if you were asked to ’ Salim shook his head. ‘That is one of the things which are not so difficult as they seem. The speed of light was discovered two hundred and fifty years ago in Europe. I’ll leave you to guess how it was done. Anyway, light reaches us from the moon in less than two seconds, because the moon is very close ; though it takes thousands of years to come from some of the stars. Well, what is light ?’

‘I don’t know,’ said Salim, wondering why he had never thought of this question before.

'Nobody else knows, either, very exactly. But it travels in waves, bobbing up and down, like waves on a stream. The size of these waves may be very, very tiny; but, if the thing we want to see is tinier still, the light waves will curl round it without touching it; so to our eyes the thing will be invisible.

'If it's *such* a small thing, it can't be very important,' said Salim.

'You're wrong, the smallest things are the *most* important. A different kind of microscope is already being made which will show us some of them; but it would take me a very long time to explain *that*. But listen to something else. Can you see in the dark?'

'No, of course not.'

'Why?'

'Because there's no light.'

'Oh, yes, there is; only it is a kind of light you can't see with your eyes. Light has different colours according to the number of wave-movements it makes every second; the size of each wave is about one hundred thousandth of an inch. If the number of waves per second becomes too low, your eyes can't see the light any more. But this 'infra-red' light makes an impression on certain chemical materials, just as ordinary light makes an impression on the film in a camera. By using these materials, you can take photographs in the dark, or in a fog.'

'That would be something useful!'

'In a few years you may be able to buy a kind of spectacles that will let you see your way on the darkest night. They began developing some such thing in the last war—like many other inventions. You must have heard of Radar?'

'I only know that it was some way of finding out when enemy aeroplanes were coming in the war.'

'It is a very clever invention, and it will lead to many others. You know how light is reflected when it strikes a mirror, for instance?'

'Yes.'

'What we call wireless, or radio waves, are very like light, only they move in very long up and down waves instead of very short ones. When they strike something, they are reflected—they bounce back. So if you send out a radio beam—a stream of these waves—and you have an instrument to record it when it comes back, you know that there must be something solid in that direction. You understand?'

'I think so,' said Salim.

'You can see how useful it is. Suppose you are flying an aeroplane at night, or in a fog, and you have lost your way. You know there may be mountains near, and you do not want to crash into them. What will you do? Just send out a beam of radio waves, and if they are reflected back quickly, you can guess that the mountain is in front of you.'

'But how far can the waves be sent?'

'Scientists have already sent them to the moon, and they have been reflected all the way back. If there was any one living on the moon, we could send signals to him in this way.'

'But *is* there any one?'

'Not unless there is some kind of creature there which can live without air. The moon has no air.'

'It would be fine to go and see!'

Mahmud laughed.

'You can go if you want to. Just pay me a few crores of rupees, and I will build a machine that will carry you to the moon—and back again, if you are lucky!'

'An aeroplane?'

'Something like a jet-propelled plane, if you know what that means.'

'I've heard of it, but—.'

'An ordinary aeroplane moves by beating the air with its propeller—as a swimmer moves by beating the water with his arms. But when you get a few miles up from the ground, there is hardly any air left. A jet-propelled 'plane is different. What happens if you blow up a toy balloon and then let go of it without tying up the mouth?'

'The air runs out quickly, and the balloon flies across the room.'

'Yes, in the opposite direction from what the air is escaping in. In these new aeroplanes you have an engine which heats gases and drives them out through a hole in the back; and this drives the 'plane forward, faster than any of the old 'planes could move. And it would still fly forward even if it were so far from the earth that there was no air left, if only it could fly fast enough to escape from the earth's attraction—the force that prevents you from jumping more than a few feet off the ground. It would fly up exactly like a rocket.'

'How fast would it have to fly?'

'A good deal faster than a rifle bullet. The difficulty is that to work up this speed it would have to carry an enormous amount of fuel. But even this difficulty will soon disappear, when we know how to use atomic energy. You have heard about the atom bombs used at the end of the last war, haven't you?'

'Yes, of course, but I don't know what they were really.'

'It would take you years to understand it properly. But you know that an atom is a very tiny particle of matter. Everything is made up of atoms of different kinds. For instance, your body—Mahmud took out a pencil and wrote down some figures—'your body consists of perhaps more than a hundred million times as many atoms as there are people living in the whole world. If you put a hundred million atoms in a row, it would be about one inch long.'

Salim tried hard to imagine what an atom would look like if he could see it ; but the effort was too much for him.

'You see how very small an atom is,' Mahmud went on, 'and yet the atom itself is a little world made up of much smaller particles moving about. In the middle of it is the solidest part, which we call the nucleus. Now the nucleus, although it is so small, is held together by a force of tremendous strength. To break off the outer parts of the atom is easy ; scientists learned to do that twenty years ago. But near the end of the war they learned how to break up the nucleus also, and so release the force that holds it together. The atom bombs exploded when a large number of atoms were broken up together, and the explosions were so terrible that each bomb destroyed a whole city and killed two or three hundred thousand people. Just think of Lahore being wiped out in one second in the same way ! '

Salim got up and walked about restlessly ; he did not like to think of it, and he began to feel that he was living in a very dangerous world.

'But, what has this got to do with the moon ? ' he asked after a minute.

‘ The point is, that the same power, which made those bombs, can be used for driving engines—railway engines, or ships, or factory machines. If you used it in a flying machine, to create the jet, we were talking of it, you would not have to carry a heavy load of fuel. A few pounds of chemicals would be enough to drive you to the moon.’

‘ Does any one really want to go there ? ’

‘ Many people have been thinking about it. It would be the most amazing adventure any human being could have ! Plans have already been made, and there is no doubt that such a machine could be built, given time and money.’

‘ It would be terribly dangerous to be flying round the moon ! ’

‘ Not more dangerous than living on this earth, if there is another war. Well, Salim,’ concluded his cousin, ‘ you must run away now and leave me to begin work, if you expect me to make any inventions ! ’

* * *

IV

HOW A NEWSPAPER GETS ITS NEWS

Sikandar's father had to go to Bombay for some business, and as the school was on holiday he took the boy with him. Sikandar had never seen the sea before. and he stood for hours on the Marine Drive, staring at it.

His father had an old friend, a Mr. Puri, who was working as a sub-editor in a big newspaper office. One day he invited Sikandar to come and see how the offices worked.

'Oh ! here you are,' said Mr. Puri, when Sikandar had found his way to the right room. 'It's a pity that today I am specially busy, but if you sit down here for a while, I'll try and get some time free.'

Sikandar sat down at a long table where half a dozen typists were typing away as if their lives depended on it. He watched Mr. Puri, thinking what a busy man he must be, but all the work Mr. Puri seemed to be doing was to pick up one telephone receiver after another—there were three on his desk, which kept ringing—and say each time : 'No ? Well, keep on trying.'

At last, when Mr. Puri's work changed into sitting still and looking at the ceiling, Sikandar ventured to ask him why he happened to be so busy that day.

'Well, you see,' replied Mr. Puri, lighting a cigarette, 'early this morning there was an unusually important bit of news. A certain foreign country, for the last two or three years, has been sending explorers to Antarctica—you know where that is?'

'Near the South Pole, sir.'

'Yes, exactly; I wouldn't like to go there myself, it's nothing but a huge desert of snow and ice—but the point is, there may be valuable minerals buried in the frozen earth there. That is what the explorers have been looking for. Several of them have lost their lives in the winter storms; but at last we have heard that they have found something valuable, not far from the coast.'

'But what does it matter?' asked Sikandar, who had been expecting to hear something more exciting.

'Exactly, my boy. What does it matter? That is just what a newspaperman has to ask about every piece of news, and we have to find out before 7 o'clock this evening.'

'Don't the people here know all about Antarctica?' asked Sikandar, who believed that in a newspaper office they must know all about everything.

'Certainly not,' replied Mr. Puri. 'Look at me, for instance. Yesterday I didn't even know that Antarctica meant the South Pole, and tomorrow I shall have forgotten it again. But today Antarctica is the only place in the world I am interested in.'

'Oh! then how can you tell the public about it?'

'We have first to get someone to tell *us*. Now, who can tell us? Nobody in Bombay knows anything about it. Nobody in India has ever been there—except one man, my boy; have you ever heard of Sir L. K. Jha?'

'No, I don't think so.'

'Neither had I, until 9 o'clock this morning; but he appears to be a world-famous geologist. You know what geology is?'

'Yes, Mr. Puri, the history of the earth and its rocks and mountains, and so on.'

'You boys now-a-days know a great deal more than I did at your age,' said Mr. Puri admiringly. 'Yes, and this man Jha once went on a scientific voyage to the coast of Antarctica, and he's written a book about it.'

'Then you should ask him about this new discovery,' said Sikandar.

'Exactly what we are trying to do,' replied Mr. Puri, banging his hand on the desk. 'The only question is—where is he?'

Sikandar was unable to think of any intelligent suggestion to make on this point.

'Jha lives in Bhatinda,' went on the sub-editor. 'He lives alone, in a very quiet way, and not many people know him. I began work this morning by sending an express telegram to our representative at Bhatinda, telling him to see Jha at once and find out his opinion. You know our newspaper has someone in nearly every town, to collect news for us.'

'I once had to send a telegram to my father, when my younger brother was born. I liked sending it very much. But it is like magic. How does it work?'

'I haven't the slightest idea,' confessed Mr. Puri, 'though I send a dozen telegrams every day, on an average. Here, Romesh,' he called out to a young man busy at another desk. 'How does the telegraph work? You know all about it.'

'It's very simple,' answered the young man. 'You have a telegraph wire strung across the country, and when you want to send a message you send an electric current moving along it. Electricity moves through copper very quickly, so the wire is usually made of copper. You keep the current flowing in short or long bursts, like short or long notes in a song, and each combination of short and long stands for a letter of the alphabet. You must have seen in post-offices the clerk sending the telegrams with a little box-instrument, where he keeps pressing a key down.'

'Does the telephone work in the same way?' asked Sikandar.

'It works with the same kind of electric waves passing through long wires. When you speak, you make sound waves in the air, which make a thin metal plate shake, and as it shakes, it disturbs the electric current and makes it stronger or weaker.'

'Well, now you know all about that, my boy,' said Mr. Puri. 'To get back to my story: a couple of hours later, our man at Bhatinda telephoned to say that Sir L. K. Jha had left for Delhi by the night train on Tuesday, and no one knew where he was now.'
'What did you do then?'

'I had to telephone to our man at Delhi. He learned that Jha had left for Bombay by air on Wednesday afternoon.'

'So he has been here all the time, while you were telephoning all over the country!'

'Yes, here in Bombay right under our noses, as they say. You saw me telephoning just now. I have men running up and down Bombay trying to find him.'

'Don't the people at the aerodrome know where he went!'

'No, they don't. I made a list of hotels, and I got from someone, who knows Jha, a list of his friends here, and my men are going round from one place to another. But so far, they haven't found a trace of him.'

Sikandar closed his eyes, partly to think, and partly because the rattle of the typewriters was making him feel sleepy. Bombay was such an enormous city—how could one man ever be found in it?

'One thing I could do, of course,' Mr. Puri went on, 'is to ask the Director of the Radio

Station to say in his announcements at five-thirty that Sir L. K. Jha is requested to get in touch with us on a matter of great public importance. But then they would ask him to give a radio talk about Antarctica, and the other newspapers would also hear of it. What we want is a 'scoop' : a piece of news that *we* know, and nobody else knows.'

Sikandar, who had opened his eyes to listen to this, closed them again.

'I've got an idea !' he cried the next moment, startling Mr. Puri, who had just picked up one of his telephones again.

'Oh ! what is it ?'

'He must have got on a ship here and sailed away !'

Mr. Puri stared at him blankly.

'Why didn't I think of that !' he exclaimed. 'Of course ! Ray !' he called out to another young man in the office —'ring up the steamship office, find out if Jha has sailed on any boat since Wednesday ! I want to go and look at the ticker, and see if there is any more news about the South pole. Come with me, my boy ; I'll show you something new.'

He hurried down the corridor into another office, followed by Sikandar, who was now wide-awake again.

They found a small box-like machine on a table. A man was standing next to it, running through his fingers a long white ribbon which came flowing out of a slot in the box as though out of a conjurer's hat.

'Anything new on the South Pole?' enquired Mr. Puri. The other man pointed to a piece of the ribbon, about twenty inches long, which had been cut off and laid on the table. Mr. Puri seized it eagerly.

'Ah!' he exclaimed. 'Look at this, my boy!'

Sikandar read, neatly printed in small letters on the tape :—

'Washington report unnamed foreign Ambassador called State Department territorial claims Antarctica.'

'You see!' cried Mr. Puri, 'some other country's Government is going to claim the area where these deposits have been found. You know we have quite a big library in our office—it's upstairs—and I went up this morning to look at some books and maps. It seems that various countries claim possession of parts of Antarctica, but they never quarrelled about it before, because there was nothing valuable to be got. Now things are different.' Mr. Puri shook his head. 'This is the way wars begin, my boy.'

Sikandar was more interested in the 'ticker' than in the news.

'How does it work?' he asked.

'Don't ask me,' replied Mr. Puri. 'I could no more explain it than I could talk Chinese. Mr. Patel here will tell you.'

The man holding the ribbon cut off another length with a pair of scissors, and explained—

'It's just a complicated kind of the telegraph system. The machine prints the messages all day as they arrive, on the tape; it works like a typewriter.'

'But who is sending these pieces of news all the time?'

'They are collected from all over the world by a company, called a News Agency. It has people working for it everywhere, and they are always sending messages to it. The Agency puts them together and sends them over the telegraph wires to any newspaper which pays it a certain sum of money every year.'

'Come along, my boy,' said Mr. Puri, who had been growing impatient, 'we must get back to my office and see what is happening.'

As soon as they entered the room again, Mr. Patel reported—

'Sir L. K. Jha left this morning at 8 a.m. on the SS. *Lion* bound for South Africa.'

'Good!' cried Mr. Puri, 'we've got him at last!' (Sikandar, who thought they had *lost* him instead, looked at his friend in surprise.) 'Run off and arrange a telephone call straightway. No, wait; send a telegram first, we had better give him half an hour to think the question over before we call him.'

Mr. Patel hurried away, and Mr. Puri sat down at his desk in great satisfaction.

'I don't understand,' said Sikandar. 'The ship must be right out in the Indian Ocean now.'

'Oh! when I said telegraph I meant radio-telegraphy, you know. We send a wireless message from the office of the steamship company, and the wireless operator on the ship hands it on to the passenger as if it were an ordinary telegram.'

'Yes, but what about telephoning?'

'The same thing, my boy. Radio-telephony. I shall just sit here and talk through this telephone to the wireless office, and there my voice will be sent out on the radio.'

Mr. Patel came back running.

'The telegram is being sent, Mr. Puri--but I've just been told that the radio-telephone system is out of order today; the transmitter they use for it has broken down.'

'Stupid fools!' exclaimed Mr. Puri, angrly, springing to his feet. 'Why must they let it go out of order today of all days?' He walked up and down the room, frowning, and then stopped at the desk and banged his fist on it.

'Sir L. K. Jha can't escape from me!' he said firmly. 'I can't get enough information out of him in a telegram. I must talk to him. Very well. I'm going to see the Editor. Look here, my boy, you had better run away now; let me see, nearly one o'clock. Come back at 7 o'clock, and I'll tell you what happens.'

Sikandar walked out of the big, crowded, noisy building, got on the electric train, and went to Juhu for a swim.

He was back at the office before 7 o'clock struck, and found Mr. Puri writing as hard as he could at his desk, which was covered with typed sheets of paper. He sat down quietly to wait, and a few minutes later Mr. Puri threw down his pen, handed three sheets of paper to a chaprasi who was waiting at his elbow, crumpled the others into his waste paper basket, and leaned back in his chair, drawing a deep breath.

'Done!' he exclaimed triumphantly. 'To-morrow in the paper you will see a whole column with big headlines at the top: *New Developments Round South Pole; Opinion of Famous Geologist.* Yes, yes; we had a very interesting talk, my boy.'

'Talk? But how?'

'How? Oh, I just went to the Editor and persuaded him to let me hire a special plane, carrying a radio-telephone. A fresh telegram had just come, saying that the President of another foreign country was making a speech about Antarctica; so our Editor saw how important it was; and after all, it only cost us a few hundred rupees, and we don't care about that. I started in the 'plane before 2 o'clock, and we overtook the *Lion* less than two hundred miles away. We flew low down, round and round the ship, and soon I was putting my questions to Jha over the radio-telephone. I took down everything he said in shorthand, got back to my office at a quarter to six, had my shorthand typed out quickly by two secretaries,—and now I've just finished writing the article and sent it to be printed. The Editor kept a whole column of the front page blank, ready for it.'

Mr. Patel came in, and said : 'The photograph is just coming through.' Mr. Puri jumped up briskly ; he did not seem at all tired.

'Come and see how we get some of our photographs ! ' he cried, and led Sikandar down the corridor again and into another big room, where people were standing round an instrument covered with knobs and dials, with a kind of square glass window under which lay a sheet of something like paper. As everyone was staring into this, Sikandar did the same, and was astonished to see a mass of tiny black dots slowly spreading over it.

'What is it ? ' he asked Mr. Puri.

'It's a photo of the coast of Antarctica, near where the discovery has been made. At least, it soon will be, I hope.'

'This is a photograph which is being sent to us by wireless from London,' said one of the others. 'You see, we couldn't find any photograph of the place in Bombay, so our representative in London arranged to have one sent.'

'We telephoned to him this morning,' explained Mr. Puri.

'By radio?'

'No, just the ordinary telephone wires that run all over the world at the bottom of the sea. Look again: do you see the picture taking shape?'

The dots had now half covered the plate, and sure enough, Sikandar could see a coast with steep white hills above the shore, and a dark narrow gully running into them.

'Wonderful, eh!' said Mr. Puri. 'Each little dot is being marked there by machine working in London, four thousand miles away. A hundred years ago it would have taken us six months to get that photo, my boy. Well, it will be in the newspaper tomorrow!'

Sikandar walked home determined to be a newspaper editor himself, and thinking of the old ways of sending messages he had read of at school. When the Spanish Armada was coming to attack England in 1588, piles of wood were got ready on hilltops from end to end of the country, ready to be set alight, so that as soon as the watchman on one hill saw the fire on the hill south of him, he could light his own, and pass on the signal to the hill northward. How rough and ready all that was, compared with the methods he had seen being used today!'

V. WHAT SOLDIERS HAVE TO KNOW

The lorry bounced over another rough spot on the road, and Krishan Dev fell off his seat near the back. He pulled himself up again, rubbing his head. His two friends next to him were still laughing, when the lorry made another painful jump, and one of them fell off the seat in his turn.

Mr. Miraj-ud-din, their teacher, helped him to pick himself up and brush the dust off his jacket.

'Never mind, you are all right,' he remarked. 'Krishan Dev, is your head hurting?'

'Not much, Master Sahib.'

'Master Sahib, even sitting in this lorry is better than sitting in school all day,' said another boy.

'Oh, is it!' replied the teacher. 'Do you want to be a soldier, Anup?'

'I am going to be one soon,' said Anup Singh confidently.

'Then you had better remember that if you keep losing your rifle in the army, in the same way as you keep losing your pencil in school, they won't let you stay in the army very long.'

The other boys laughed at Anup, who was always talking about how he meant to win ten medals and rise to be a General ; but the noise of the lorry became so loud that when he tried to answer, nobody could hear what he was shouting.

'At last they reached the big *maidan* outside the town, where the parade was going to be held. There was already a crowd sitting or standing along both sides of the ground, but a space had been kept for the boys, and Mr. Miraj-ud-Din took them along to find it.

'Now,' he said, when he had got them to the right place and counted them, 'watch carefully, and you will see how a modern army fights. Look—it's beginning.'

The parade went on for nearly two hours, and all the time they were happy and excited, except when they remembered that next day in school they would probably have to write an essay about what they had seen.

First of all there were columns of soldiers, from different regiments, marching across the field, while the bag pipes played ; then some of the soldiers came on at a run, arranged in small groups falling down flat on the ground sometimes to fire their rifles with blank cartridges, or rolling over and pretending to be dead, or driving their bayonets into sandbags hanging from posts ; all this gave a good idea of how an infantry charge is carried out on a battlefield. Stretcher-bearers came hurrying up to carry off the 'wounded,' and some real hand-grenades were thrown at a small wooden hut standing in the middle of the *maidan*.

Then guns of different types and sizes appeared, some drawn by teams of horses but most of them attached to motor carriers or tractors. Machine-guns were fired at a big target at the end of the field, and small tanks began crossing the *maidan* at full speed, over ditches and low earth walls that had been dug across it.

At the end a few big tanks rolled forward, more slowly, making a tremendous roar, and three aeroplanes suddenly swooped down from above, one after the other, to within a few hundred feet of the tanks. The aeroplanes tried to hit the tanks with toy bombs which they dropped, and which gave out clouds of smoke as they touched the ground. One 'bomb' fell within a yard of a tank, and the crew came hurrying out and running away as if their machine had really been set on fire.

A V.C.O. who had been with the infantry came round to where the boys were standing, and shook hands with Mr. Miraj-ud-Din.

'Oh, uncle!' cried Anup Singh. 'We've been watching all the time; uncle! can you give me a ride inside one of the tanks?'

The officer laughed.

'I might be able to, if your teacher will let you come—but I can tell you that you won't enjoy it, my boy.'

'Oh yes, I will. Master Sahib! Master Sahib!!'

'Don't shout, Anup, you make as much noise as a machine-gun. All right, run along.'

Anup followed his uncle, boiling with excitement, to where the line of heavy tanks was getting ready to 'attack' again. The officer spoke to some men near the first huge machine, and Anup was pushed up on to it and pulled down inside through the narrow hatch.

At first he could hardly see anything; there were only a few cracks through which light came. He had just discovered that he was sitting behind the driver, on a kind of iron stool, when there was a sudden lurch, and the tank began to move.

It was soon moving at full speed, and Anup felt as if he were rolling down a hill-side in a fog; through the narrow slit in front of the driver he could see only a thin strip of the sky. He did not know they had reached the corner, when the driver pulled back the right hand one of two thick steel levers he was holding; and the tank spun round to the right, while there was so much noise of grinding and creaking that he thought the machine must be falling to pieces. If someone had not put an arm round his shoulders, he would have gone flying off his stool into the iron wall. And before he had pulled himself together, the nose of the tank seemed to stand up in the air and then fall back with a crash. They had crossed a four-foot mound, but if Anup had been told that they had jumped over the moon, he would almost have believed it.

When they stopped at last and he was pushed up through the hatch, he found his uncle sitting on the top waiting for him.

'Didn't I say you wouldn't enjoy it?' asked the Captain, smiling.

'I did enjoy it,' said Anup, breathing hard to get the dust and petrol smell out of his nose. 'Uncle,' he asked, to try and forget that his head was spinning round and round, 'what are those levers the driver pulls, at each corner?'

'I suppose you expected him to be holding, a wheel, like a lorry-driver! No, a big tank is too heavy to be turned by a steering-wheel. You see this sort of steel belt on each side that carries the tank. It runs over this set of cog-wheels here, just as the chain of a bicycle goes round and round; the engine drives the wheel, and the wheels move the belt. Well, when the driver pulls one lever, the belt on that side of the tank is locked, while the other one goes on, so the tank spins round to one side. Understand?'

'Yes, uncle,' said Anup, who had not been listening but was now beginning to feel better.

'Aurangzeb would have given a good many of his elephants for one of those tanks!' said the Captain. 'He could have conquered the Deccan with it in a month. The Germans conquered France in three weeks in 1940, with a few hundred tanks not so good as the one you were in.'

'When were they first used ?'

'About 1917, in the first World War. They were invented because each side had been trying to beat the other with infantry charges, and they found that their soldiers were just being wiped out by machine-guns. Those machine-guns you saw today, can fire hundreds of bullets a minute, you know. At first the tanks were little things, hardly twelve feet long, and even the one you were in is small compared with some that were used in the last War, that weighed a hundred tons—as much as the first ships that sailed round the world in the 16th century.'

The other boys crowded round Anup who was by now well enough to feel quite proud of himself.

'Well, sir !' said the Captain to Mr. Miraj-ud-Din, 'my nephew has had enough of excitement, but if the rest of your youngsters would like some, I could arrange for them to have an aeroplane trip ; those Air Force planes are taking people up for rides at the aerodrome over there.'

Before the teacher could say anything, the boys were all running across the maidan towards the aerodrome, with Anup at their head.

Groups of people were standing beside the air strip, waiting for their turns, and every few minutes an aeroplane came down, took on board a fresh set of passengers, and roared off again. The surface of the aerodrome was very dusty, and the whining propellers sent thick clouds of dust flying all round them.

The Captain made Anup, who had with him his friends Krishan Dev and Sikandar, wait until all the other boys had got off. Then at last, burning with impatience, the three were allowed to climb up into the tiny cabin of a waiting machine.

A mechanic was standing at the front, and he spun the propeller round and then jumped out of the way ; the engine gave a sudden roar.

The plane began to glide smoothly across the landing-ground. They were sitting in low padded seats, as though in a motor-car, with the pilot in the left-hand front seat. Although they were looking down all the time through the windows, they could hardly tell at what moment the plane left the ground and they were in the air for the first time.

The plane rose in a steep half-circle ; the aerodrome dwindled below them, and the town on one side and a chessboard of fields on the other came in sight.

'Higher !' shouted Anup to the pilot—he was sitting in the other front seat.

The pilot looked round mischievously, and moved the long thin lever, with a round knob on the top, which came up between his knees..

Krishan Dev gave a howl of alarm, and Anup almost did the same. This was worse than the tank. The plane had suddenly turned on its side, the right wing dipped down out of sight, and through the glass on that side they could see nothing but empty air, and the ground far below.

A moment later they were flying level again. Krishan Dev closed his eyes.

Then he opened them with a jerk and howled again ; the plane had suddenly plunged straight down for fifty feet, and they all felt as if their stomachs had rushed up into their lungs.

'Are we falling ?' gasped Anup to the pilot, who only smiled mischievously and turned the plane over on to its left side.

This time it was not quite so bad, and though it made them nervous, as they came down, to see the aerodrome rushing up towards them, they were able to thank the pilot quite cheerfully as they at last scrambled out.

'How did you like it ?' enquired the Captain, coming up. 'Come along, you'd better sit down here for a few minutes before we go and find the others. Well, Anup, are you going to join the Tank Corps, or the Air Force ?'

'The Air Force !'

'You think it's all excitement being a soldier, but most of it is just sitting in a class-room learning lessons. For instance, you'ld have to learn all about how an aeroplane engine works.'

'I know all that already,' said Sikandar; at least, if it's the same as a motor-car engine.'

'Much the same, only many times more powerful,' returned the Captain. 'All right, tell us how it works.'

'You put oil in it,' began Sikandar, 'and the oil is forced into a cylinder so that it turns into a cloud of little drops, and then an electric spark makes it explode into gas, and the gas forces the loose end of the cylinder to move back, and that drives the axle-wheel round, and that turns the other wheels.'

'You seem to be quite a mechanic already!' exclaimed the Captain. 'Yes, that's how we drive cars and aeroplanes, and tanks as well. Do you know how much an aeroplane costs to build?'

'Two crores,' replied Krishan Dev, who was always weak at arithmetic.

'Good heavens! No, but a really big aeroplane might cost about twelve lakhs, and that's quite enough. With twelve lakhs the Government could run forty or fifty schools like yours for a year. If you wanted to build a really big battleship, you would have to spend about seven crores—and you might lose the ship in five minutes in a battle.'

'Why does it cost so much?' asked Anup.

'A warship is a very complicated thing; it takes years and thousands of men to build it. A hundred-and-fifty years ago they were made of wood, and the guns were just lined up on the deck and fired by men standing round them. But what happens in a battle now? The gunners are hidden in a steel turret like a beehive; they can't see anything, and in any case the ship they are firing at may be fifteen miles away,—almost out of sight.'

'Then how can they know where to fire?'

'They are told what to do by a whole set of men in different parts of the ship, working together with special instruments. They have to know how far away the enemy ship is, how fast it is moving, and which way—as well as how their own ship is moving. The shell they fire may weigh thirty maunds, and it goes up in the air for miles before it comes down—ten times as high as you went in the aeroplane. If there is a wind blowing, that will change the course of the shell slightly; the ship is rolling from side to side in the waves, and that alters the position of the guns every moment. All these things have to be worked out in a few seconds, and it would take hours for the best mathematicians in the world to calculate them. So it has to be done by machines.'

'But how can machines count?' asked Sikandar.

'Machines can be made that work much faster than a man's brain. You can see them in banks; they are called adding machines.'

'But are those gunners ever able to hit the enemy?'

'Oh, yes. But you see that to be a gunnery officer you have to know a great deal of mathematics. It's the same in a land battle. Suppose you are firing at an enemy who is out of sight, what will you do, Anup ?'

'Wait till the enemy comes near, uncle.'

'If you wait, you will be dead long before you see him. Well, one way is to measure the waves made by the explosions of the enemy guns through the ground. You know how an earthquake makes the ground tremble ?'

'Yes.'

'That trembling moves through the solid earth like a wave running over the sea ; it spreads out in a circle. Now a big gun's firing shakes the ground in the same way, and with special instruments you can detect the ripple. You measure it from different points, and calculate from them where the centre of the circle is, just as you do in geometry lessons at school. Then you fire at the centre of the circle, and hit the enemy.'

'All this sounds very difficult,' said Anup doubtfully. 'I would rather have been a soldier in the old days, riding a horse and waving a sword.'

'And wearing armour ? Have you seen the old suits of armour in the museum at Lahore ? I once put on a suit of chain armour, and a helmet, and they were so heavy I could hardly stand up. Think of wearing them in the hot sun all day. No, Anup, wars have never been very pleasant, and never will be. I hope there never will be any more.'

VI. THE DOCTOR'S WORK

Madan Mohan had been suffering for a month from a very bad cold on the chest. He coughed so much that his mother became frightened. Dr. Pillai gave him medicines, and examined him twice by making him lie down with his shirt off, tapping his chest and back, and listening through the stethoscope to the sound of his breathing.

After each examination, he told Madan's mother that there was no serious trouble : it was nothing but a bad cold. But she had got it into her head that there must be something wrong with the boy's lungs. She insisted that they should be x-rayed ; and at last, to satisfy her, the doctor took Madan off with him one morning to the hospital.

On the way, in his car, he told Madan not to feel nervous, because the x-ray test would be quite painless.

'I don't suppose you know what x-rays are,' he remarked.

'No, I don't,' Madan answered.

'They are a form of radiation, just as light is, but they were only discovered a few years ago. Radium gives out x-rays, along with certain small particles ; and so do a few substances like platinum, when they are bombarded with electrons—that is, with the tiniest of all articles, broken off from their atoms.'

'But how can you take a photograph with these rays?'

'They are useful because they move in very short waves—much shorter than light-waves or electric-waves; and they can pass through skin and flesh, just as light goes through glass, and affects a photographic plate on the other side. But bones, or anything hard, may stop them. An x-ray photo shows you as a kind of skeleton. Suppose you have swallowed a nail; the photo will show the doctor exactly where the nail is, and then he can remove it.'

'But I haven't swallowed any nails!' said Madan.

'No, but if there is anything seriously wrong with your lungs, the photo will show a dark patch of shadow on them. But don't worry; there won't be any patch: you haven't got tuberculosis!'

At the hospital, after some delay, Madan was taken into a dark room, where he had to pull his shirt off and stand on a low platform, pressing his chest against a metal frame. Behind was a big machine, which looked like a magic lantern, pointing at his back. He could not help being rather nervous; but it was all over very quickly. The machine made a buzzing noise for a moment, and then Madan was told he could go away. As the doctor had told him, he felt nothing at all.

The doctor wanted to meet a friend of his who was working in the hospital, and as they had to wait for some time he took Madan round the building. They walked down long corridors where nurses in uniform were hurrying about, and peeped into the big rooms, with rows of beds on each side, where the patients were lying.

'This is all very different from the way sick people used to be treated in the old days,' remarked Dr. Pillai. 'Medical science in Europe began with the ancient Greeks; they made a few discoveries, but most of their ideas were wrong. In the Middle Ages doctors tried to cure their patients by making them swallow powdered horn, and dried toads, and all kinds of horrible and useless things.'

'They must have made the sick people worse still, I should think,' said Madan.

'They must have *killed* a great many people, who might have recovered if they had been left alone. Even to-day, you know, fewer patients are cured by us doctors than by Nature—that is, by their own natural bodily strength.'

'Swallowing toads wouldn't give any one much strength!'

'No, and even in the 18th century, the chief remedy used by doctors was drawing part of the patient's blood out of him. It was called 'bleeding'. They either cut a vein and let the blood flow out or put a leech on the patient's arm to suck his blood. But now we know that our blood is the most valuable thing we have, to restore us to health : all that bleeding was far worse than useless.'

'People say that in India, in old days, there were good medicines.'

'Quite true ; many medicines made from herbs, which the Western doctors have not studied enough. But some of them have been lost ; and in India we have had too many ignorant men pretending to be doctors. I knew one fellow, when I was a boy, who used to seal up every door and window of the patient's room, so that his soul couldn't fly away and escape. But, of course, the patient usually died all the more quickly, because fresh air is one of the most important things we need for health.'

'Did they know how to do operations here in old days ?'

'We have a few surgical instruments in our museums, made by the ancient Indians : but we don't know much about how they were used. Of course, in operations to-day very complicated instruments are needed. For instance, the surgeon sometimes uses an electric wire, instead of a knife, to cut through delicate parts of the body. It prevents the veins that are cut from bleeding.'

'I should be very frightened if I had to have an operation !'

'Most operations are not dangerous nowadays. They were until not long ago, partly because they were so painful. Imagine what it was like for wounded soldiers to feel their arms or legs being cut off !'

'Terrible!'

'Yes, but nearly a hundred years ago, chloroform was invented, and then other drugs too, which prevent the patients from feeling any pain. But still, most of them went on dying, and no one knew why, until microbes, or bacteria, were studied by the French scientist Pasteur. You must have heard of him?'

'Yes, I have seen his name in a book.'

'Microbes are very minute forms of life; they float in the air, or live in water, or are carried about by animals in their skins. They exist everywhere, in fact, and when the harmful ones get into your blood they poison it. Surgeons used to wash the knives with water, but that was useless. Boiling water kills many microbes, and we have found substances called antiseptics, which destroy others. People don't usually die under operations now, because the microbes are not allowed to get into their blood. A hundred years ago, after a battle, the majority of the wounded soldiers died; now the majority of them recover.'

'Are all microbes harmful?'

'Oh, no. It is one kind of microbe that turns milk into *dahi* or cheese. But many are deadly to human beings. The way to escape them is to wear clean clothes and live in clean rooms. Dust attracts insects, and insects often have microbes living inside them, which pass into your blood when the insect bites you.'

'What kind of insects ?'

'Plague-microbes, or germs, are carried by fleas ; which often pick them up by crawling into the fur of a rat infected with plague, and sucking them out of its blood. The insect which spreads more diseases than any other is the louse. Lice live in dirty clothes and dirty hair ; the worst microbe they put into your blood when they bite you is the one that causes typhus.'

'Do many people in the Punjab catch typhus ?'

'Not many, but we have other diseases that come in epidemics, attacking a great many people at the same time, because our towns are dirty and overcrowded. In the West, most of these epidemics have been stopped ; but in England in the 14th century an outbreak of plague killed nearly half the population of the country in a few years.'

'What does a doctor do if the microbes have already got into someone's body ?'

'He injects something into the person's blood, either to kill the microbes or to destroy those elements in the blood that the microbes feed on, so that they die of starvation. Otherwise each microbe divides into two, and those two divide again, till in a short time there may be millions of them inside the patient's body.'

'What is this thing, penicillin, that everybody is talking about ?'

'It is a wonderful cure discovered in the last War. It is made out of a certain kind of moss, and when it is injected into the blood it destroys the germs that cause quite a number of different diseases. Only it has to be injected several times, after every three hours, so the poor doctor may have to sit up all night with his patient!'

'Why is our blood so important, doctor?'

'First of all, because it carries through the body the valuable substances that your stomach extracts from the food you eat. This is why, when an injured person has lost too much blood, we transfuse blood into him from a healthy person; we pump a certain quantity of blood from one man's veins into the other's.'

'Is that bad for the one who is giving the blood?'

'It leaves him rather weak for a time, that is all. Only different people have slightly different kinds of blood, and you have to make sure beforehand that both the two persons have blood belonging to the same type. But blood is not the only part of the body that can be exchanged. What do you think of exchanging eyes, Madan!'

'Surely that isn't possible, doctor!'

'Oh yes, it is. If a person had lost an eye, you can remove the eye of another man who has just died (after a battle, for instance) or a part of the eye of an animal, if your patient has only lost part of his eye, and fix this into his eye-socket. The nerves can be joined on to those of the brain, and he will be able to see again.'

'I can hardly believe it! When a man is dead, isn't every part of his body dead?'

'A body is made up of millions of tiny parts, called cells, which grow together in groups. They divide and increase in number, just as germs do; that is how a child grows up. Well, you can take a group of cells from a body, and keep them alive as long as you like, with proper chemical treatment. You can even remove a whole organ, an animal's heart, or liver, and keep it alive, if you want to study it.'

'Could you join a lot of them together and make a new animal?'

'No, we haven't learned to do *that* yet!' replied Dr. Pillai, smiling. 'But we can repair a damaged body. You can remove a piece of skin from one part of a man's body, and make it grow on another part, where he has been injured. Sometimes, you know, people's faces are very badly burned—all the skin is destroyed. The surgeon will take such a patient and give him a new face, by removing small pieces of skin, one by one, from his legs or arms (where the skin soon heals up again) and making them grow over the burned part. If he has a photo of the patient, he will make the new face as much as possible like the old one, so that the patient's friends will still be able to recognise him.'

'If the doctors have made so many discoveries,' said Madan, 'why does anybody still die ?'

'There are some diseases, like cancer, which even now we can't always cure. And we can't stop people from dying of old age. But a great many lives are saved nowadays, especially children's lives. Seventy-five years ago, in England, fifteen babies used to die out of every hundred born in a year. Now only five die.—Well, I think I can find my friend now ; will you wait for me in the car for a few minutes ?'

Next day Madan was shown the photograph of his chest, with the shadow-lines of his ribs running across it, and was told that there was nothing wrong with his lungs. His mother said that Dr. Pillai must be a very clever doctor.

VII. WHAT THE EARTH HOLDS

The engineer stared hard at the sheet of paper in his hand, and finally shook his head.

‘ No luck again,’ he said. ‘ Well, we must go on trying. You men go down to the hut and have your food, I’ll follow you in a few minutes.’

The workmen turned away, wiping the perspiration off their hot faces, and set off along the little track down the hill-side, while the engineer continued to sit on his rock, looking thoughtfully again at the paper.

Zaman Khan, who had been lying for half an hour behind some bushes, watching, could not check his curiosity any longer. He ran out from behind the bushes towards the engineer.

‘ Hullo ! ’ exclaimed the latter—‘ Where have you come from so suddenly ? You made me jump ! ’

‘ I was over there,’ said Zaman Khan, not feeling sure whether the stranger would want to talk to him. He pointed towards his bushes. I am staying near here for my holiday, and this morning I came out for a walk ; and when it got so hot, I lay down to take a rest.’

‘ I see ; but why have you come running here all of a sudden ? ’

'I was watching you and those men,' confessed Zaman Khan, 'and I was wondering all the time what you were doing here. So I came to ask you. Please excuse me.'

'That's all right,' said the engineer, with a good-natured smile. 'Whenever you want to know something, ask.' He folded the sheet of paper and put it in his pocket. 'What's your name, my young friend?'

'Zaman Khan. I belong to Rawalpindi.'

'Zaman Khan, eh? That's a fine name. Do you ever think what it means: 'the lord of the universe?' We give ourselves wonderful names in India, don't we! Still the human race is going to be the lord of the universe, with the help of science.'

'Come and sit down here. Now, what do you want to know?'

'What work are you doing here?' asked Zaman, sitting down next to the rock.

'I can tell you that very simply. We are looking for oil.' 'Oh! Where?' 'Under the ground, of course. Deep down. Those workmen you saw have special machines, which we call borers. They drill into the earth for hundreds of feet, and they have small scoops at the end; so when we pull them up and see what is in the scoops, we know what is lying hundreds of feet below us: stone, sand, clay, or whatever it may be.'

'But you have not found any oil?'

'No, we are having bad luck. We have been drilling holes for a week now, in this neighbourhood.'

'If you have to go all over the country doing it, it will take you years!'

'We shan't do that; life is too short, Zaman. We have ways of guessing which are the best districts to search. For instance, here, along the edge of the Khewra Hills, we may expect to find some oil.'

'How do you know where to look?'

'We usually find a particular mineral lying in similar parts of the earth's crust. When you know that there is rock of a certain kind, lying under the ground in a certain formation, you can guess that a certain mineral will be there. In the case of oil—you know where oil is found in India?'

'Yes, at Attock.' 'But there is not enough of it. We need more. Burma has plenty; Persia is full of oil; so is the part of southern Russia round Baku. Some scientists believe that there must be a great chain of lakes of oil, deep down, stretching from Baku through Persia to India.'

'If so, we must try and find it, as quickly as we can.'

'I know oil is very important,' said Zaman. 'We learn about it in our geography lessons, and my father is always reading something about it in the newspapers.'

'It's very important, indeed. Oil is being used all over the world in huge quantities, for driving motor-cars, ships, aeroplanes, and so on.

We have been using it so quickly for the last twenty years, that most of the world's oil-wells may be dry and finished before long. The Russians have even been thinking of trying to extract oil from below the bottom of the Caspian sea. Russia and America have the biggest supplies, you know.'

'Yes, I know that,' said Zaman. 'Your work must be very interesting. I should like to go in for it.'

'Well, perhaps one day you will. The Government needs a great many trained men —geologists, as we call them, who have studied the earth and what is inside it. It is not only a question of oil ; we shall have to search the country for many other minerals as well.'

'How many minerals are there in India ?'

'A fair number, but we hope to discover more. We have one or two very rare ones ; for instance, uranium, which is the most dangerous stuff in the world, because atom bombs are made out of it. It is one of the many radio-active materials—that is, materials which give out energy and gradually turn into something different.'

The engineer laughed.

'It reminds you of the old Philosopher's Stone, doesn't it ?' he remarked.

'What was that ?'

'In the Middle Ages, before science began properly, men were always dreaming of turning one metal into another with the help of a magic stone. There was once a man who said he could make lead change into gold, so the king locked him up in prison with a heap of lead, and told him he could come out when he had turned it into gold. But now, you see, we know that some minerals do really change, by themselves.'

'Into gold ?'

'No, unluckily—into lead, in the end ; but the energy they give out while they are changing can be useful to us. Radium, the chief one among them, is used for curing diseases, like cancer. Still, they are not the most important minerals we have to look for.'

'Coal is the most important, isn't it ? and we have plenty of it in India.'

'In a way, yes. We have a little in the Punjab and C.P. and a great deal in Bihar. But unfortunately most of it is of an inferior sort. We have not very much left of the finest coal, which is used for smelting steel and other purposes. In fact our good coal may be used up in a very few years from now.'

'Then what shall we do after that ?'

'We can make use of other sources of power ; we can run our railway engines with electricity, for instance. But coal is a wonderful thing. Our best dyes, and some of our most valuable medicines, are extracted from coal.'

'Out of ordinary black coal !'

‘ Yes. Scientists don’t care what a thing looks like, you know ; they are only interested in what it contains. Oil, too, is extracted from coal countries like Germany which have no oil-wells.’

‘ I suppose,’ Zaman said after thinking for a minute, ‘ all the minerals in the ground will be used up one day.’

‘ Yes ; at least, all those lying close under the surface, where they can easily be dug out. All the centres of the earth probably consist of heavy metals like iron. Ages ago, when the earth was a flaming furnace, the heaviest materials would naturally sink towards the centre. Further up is mainly rock—the heaviest kinds of rock underneath, the lighter ones nearer the surface. Our minerals are just scattered in odd pockets in the earth’s crust, and so far we have only dug down a very short distance.’

‘ How far ? ’

‘ Well, take the famous gold mines in S. Africa. Some of them go down nearly 9000 feet—nearly two miles ; and there are plans for making them deeper still. It is very hard, indeed, to build such mines so that the walls of the shaft will not collapse ; and very hard for human beings to work at such a depth, because it is very hot and there is no fresh air. But it may become necessary to make much deeper mines in the future. Still, the common metals will last for a long time.

In Russia, for instance, one of the Ural mountains is an almost solid block of iron, containing hundreds of millions of tons of ore.'

'The Russians are lucky, then,' said Zaman.

'Yes. But some minerals lie in very awkward places. Bolivia, in S. America, is full of tin ; but to transport it down the Andes mountains to the coast, to be shipped to countries that want it, is extremely difficult. Or the stuff you want may be hard to separate from other things you don't want. There is plenty of gold dissolved in the sea, and it's possible to extract it. Out of one cubic mile of ordinary sea-water you could extract gold worth six crores of rupees ! ' Zaman's eyes shone.

'Then why don't we do it ! ' he cried. 'We should become the richest country in the world ! '

The engineer smiled.

'We don't do it,' he answered, 'because the cost of extracting the gold from the sea-water would be about thirty crores—so at the end of our work we should be much poorer than when we began. Perhaps when you grow up you will invent a cheaper method of extracting gold from the sea.'

'I don't think that is very likely,' said Zaman philosophically. 'But tell me, please, how did men get their metals in the old days, before they learned to make deep mines ? '

'Well, in the first place, they used metals very little, compared with us. To-day each big country makes millions of tons of steel every year. Every day we use hundreds of things made of metal, from cooking-pans to motor-cars. In the old days, one of the chief uses of metals was for weapons and armour, and these things were expensive; so only a few men could have them, and they were able to rule over the rest of the people.'

'But where did the metal come from?'

'Wherever it could be found lying near the surface. For a very long time the Chinese have been working shallow coal and iron pits, and the Persians used to collect oil for their lamps from shallow wells. One strange source of supply was a meteor.'

'What is a meteor?' asked Zaman, who thought he had heard this word before, but could not remember what it meant.

'A meteor is a block of stone and metal flying about in the sky. They travel in big swarms, and as the earth moves through space, thousands of meteors collide with it every day. Most of them grow red-hot from friction while rushing through the air, and melt away into gas—we often see them shining in the sky; people call them shooting-stars. That is lucky for us, because if they all fell on the ground they might kill a great many of us. Very big ones do sometimes reach the earth; an enormous one fell in Siberia, ages ago, and made a huge hole in the ground, like a shell exploding. But I was going to tell you that an explorer in Greenland, in 1894, discovered a metallic meteor, weighing thirty-seven tons, and he found that for a hundred years the Eskimo hunters up there had been breaking bits of it off to use for tools and weapons.'

'Thirty-seven tons!' cried Zaman. 'What, if a meteor like that fell on Rawalpindi?'

'It might happen any day, but don't worry—it's very unlikely.' 'But in ancient times, how did people first come to think of using metals?'

'Probably at first they discovered them by accident. The first human beings on the earth, in what we call the Stone Age, made all their tools out of stone or wood. The difficulty about using metals is that they rarely exist in the ground in a pure form; they are mixed up with other materials. We call the mixture an **ore.** You have to get the ore, and heat it in a furnace until the metal you want melts and runs out. But it happens that in some parts of the world you may find pure metals lying near the surface. Copper was being used in what is now Iraq, at least six thousand years ago. Then, perhaps, while lighting their camp fires in places where copper ore was lying, men found the copper melting and flowing out; so they learned to build fires, especially for this purpose. Nowadays we have huge furnaces to do the work—we call it smelting an ore. Some of the biggest furnaces in the world are in India, at Jamshedpur.'

'Was copper the first metal to be used?'

'Probably. It is easy to hammer into any shape you want; but it's too soft to be useful for things like swords. Next came bronze. You know what that is?'

'A mixture of copper and tin,' answered Zaman readily.

'Yes, a mixture or an alloy as we say. In Iraq, tin and copper ores sometimes lie together, and by melting them together men may have learned accidentally that the alloy was harder than either tin or copper separately. That was the beginning of the Bronze Age, when nations which knew how to make bronze swords were able to conquer others and occupy new countries. That is how the ancient Britons occupied Britain before Julius Cæsar went there.'

'But iron is harder still,' said Zaman. 'Why didn't they use iron?'

'The Iron Age came later, because iron is harder to smelt. It needs a very hot furnace. Tin melts at 200 degrees centigrade—twice the heat of boiling water—and copper at 1100; but iron must be heated to 1500 degrees. The Romans conquered their empire partly because they had a supply of very good iron for their swords, from Spain.'

'And what about steel?'

'Steel is an alloy of iron with a small amount of carbon. And there are many steels made for special purposes which contain other things as well, such as chromium and nickel. In fact, there are hundreds of alloys used in modern industry, made by mixing different metals in different proportions. One part of aluminium with nine parts of copper gives you an alloy three times as strong as copper. Pure metals are not used very much. Pure copper is used for electric wires, tungsten is used for the very delicate wires inside electric light bulbs. But usually alloys are employed.'

'Why is an alloy harder than the metals it is made from?'

'That isn't an easy question. If I had a microscope here, I could show you what a very thin slice of metal looks like, magnified a thousand times. Instead of a plain surface, you would see a criss-cross of fine lines, because the metal consists of numbers of tiny grains, like grains of sand, packed close together. But each of these is made up of countless atoms, and although we can't see these atoms we know that they are arranged in each metal in a particular pattern, or design. You see what I mean?'

'Yes,' said Zaman after thinking for a few moments.

'Now, when two metals are melted together to form an alloy, it is like salt dissolving in water. The two patterns of atoms are forced together, crushed into each other, and that makes a new pattern, which holds together more solidly than either of the old ones. But all this is difficult, isn't it? It is easier to understand how metals are used than what they are made of. Do you know how many metals there are?'

Zaman hastily counted all he could think of and said—'About ten'.

'About forty—from the heaviest metal, osmium, to the very light metals, like aluminium and magnesium. These light ones were discovered not many years ago, but they —or rather, alloys of them—are very important; especially for aeroplanes, which have to be as light as possible. By the way, we were talking of sea-water; magnesium is actually being extracted from the sea. A cubic mile of sea-water contains six million tons of it.'

When Zaman had thanked the engineer, and was walking home, he made up his mind to be a geologist or an engineer himself one day.

VIII. A VISIT TO THE RADIO STATION

Hitindra Singh had come out for a walk, and as he passed Simla Hill he turned off and walked a little way along Empress Road to stare at the great iron gates of Government House, with the sentries standing behind them.

He was just turning to come back, when he noticed another sentry with a rifle standing at an open gate. Looking up at the building behind, he saw written in big blue letters: ALL INDIA RADIO.

Hitindra was fond of listening to the radio, so he thought it would be very interesting to go inside the building and see what was happening. But as soon as he approached the gate, the sentry pushed out his rifle—which Hitindra now noticed had a bayonet stuck on it—and asked for his pass.

While he was hesitating, a car drove up and turned into the gate. As it slowed down, Hitindra saw looking out of the window at him Professor Nizami, who lived in the house next to his.

The Professor stopped the car and came out.

‘ Hullo ! ’ he said. ‘ Are you trying to get in here ? ’

‘ Yes, sir,’ answered Hitindra. ‘ But the sentry won’t let me.’

'He won't mind if you come in with me. I'm going to give a talk—come along.'

They went in, and along a corridor, to where two officials were sitting at a desk. One of them got up and shook hands with the Professor, and took them into a nearby room, marked No. 4. It had a big green-cloth-covered table, on which stood a microphone with a shining metal chair in front of it—all the furniture was of chromium-plated metal. Just over the door, both inside and outside, was a kind of short glass tube; and a big clock hung on the wall. The walls were covered with something that looked like cork, to make them sound-proof.

The Professor sat down in front of the microphone and drew it up in front of him, about fourteen inches from his face. The official switched on a big reading-lamp, and took out of a drawer half a dozen sheets of typed paper. Each of these he fastened with clips on to a sheet of cardboard.

'This is the talk I am going to read,' Professor Nizami explained to Hitindra. 'It's about the weather: I hope that doesn't seem to you a very dull subject. We fasten the sheets on to cardboard so that they won't rustle when they are turned over, because the microphone catches the slightest sound and magnifies it. Well, just make yourself comfortable on the sofa over there, and let me get ready. I have to practise a little first.'

The official went out, and the Professor began reading the first page. Every minute or so the official put his head in at the door and said, ' A little louder, please, ' ' A little further from the microphone,' or some such thing. Finally he seemed to be satisfied, and came and sat down opposite the Professor, putting a pair of ear-phones over his head.

' Three minutes left,' remarked the Professor, glancing at the clock. ' They were listening from the control room,' he went on, to Hitindra, ' to make sure that my voice sounded all right. Now remember : as soon as you hear a click, and that glass-tube over the door turns red, this studio will be ' alive ', and if you make any noise it will be heard on everyone's radio-set. So keep quite still until the red light goes off.'

They sat in silence, and Hitindra thought that if he were in the Professor's place he would be feeling very nervous at having to talk to an invisible audience. Faintly he could hear a musical programme coming from the earphones ; then this changed to a voice from another studio, making the announcement of the talk. Suddenly, the glass-tube turned red, and the Professor began to speak, while Hitindra sat on his sofa in the corner, hardly daring to breathe.

He was amused to see that the talker grew quite excited as he went on, and waved his hand and looked round, just as if he were in his class-room lecturing to his students. What he was saying sounded rather difficult, and Hitindra decided to ask him some questions about it afterwards.

As the finger of the big clock approached ten, the Professor, who kept looking up at it, quickened his speed a little. He finished with fifteen seconds to spare ; the official held up his hand warningly for silence, until there was another click and the red light went out.

The Professor threw his papers down on the table and stretched himself, drawing a deep breath, while the official removed his earphones and congratulated the Professor on his talk.

'Can I see the control room ?' said Hitindra.

'I dare say, Mr. Gupta here will let you have a look,' said the professor, glancing across the table at the official who smiled.

'Oh, yes. Come this way.'

He led them further down the corridor, to an open court at the back of the building, and opened the door of a room to the left. Here one of the engineering staff was seated at a desk covered with knobs and dials. He also had a pair of earphones on his head, and was looking at a stop-watch in front of him.

Hitindra was not sure whether he was allowed to speak here, but Mr. Gupta began showing him the instruments that crowded the room, explaining how the sound was controlled by means of the row of tall metal cupboards standing against the wall. It looked very complicated, with the dozen dials set in front of the machines.

'So the sound goes out from this room all over the Punjab,' said Hitindra.

'Oh, no,' returned Mr. Gupta, 'the sound only goes along a special telephone wire to the transmitter, a few miles away. Haven't you seen those tall metal towers, out on the Grand Trunk Road? That is where the really important machinery is kept, and where the sound is broadcast from. The engineers there have to be always on the watch, because all sorts of atmospheric conditions affect the clearness of the transmission, and they have to keep altering their instruments accordingly.'

'I remember,' remarked Professor Nizami, 'the Delhi Radio Station used to have a studio at Simla in the summer months, when many of its talkers had gone away up there. The programme was telephoned all the way to Delhi and radiated from there, and a listener in Simla could hear each sound on his wireless set only a moment after it left Simla. The radio is really an amazing invention!'

'The Delhi Station is much bigger than ours,' Mr. Gupta said to Hitindra. 'It has one of the most powerful transmitters in Asia, and they broadcast programmes to foreign countries as well. You should see the new studios in Broadcasting House at New Delhi; they are very fine and up-to-date.

'Is this a gramophone over here?' asked Hitindra, pointing to a machine in the corner.

'Yes, a kind of gramophone,' replied Mr. Gupta, 'which we use for recorded programmes. For instance, someone in London may be making an important speech, which the public here would like to listen to. If it is at a time when we are broadcasting, we can pick it up on our receiver and relay it simultaneously from our transmitter as part of our own programme. But it may not be at a suitable time.'

'You know, Hitindra,' put in the Professor, 'nine o'clock in the evening in London is about 2-30 a.m. here, when everyone is asleep.'

'In such a case,' Mr. Gupta went on, 'we can pick up the broadcast and record it on a gramophone disk, and broadcast it next morning. You understand how a gramophone works; the needle runs through a groove, which is deeper or shallower, according to the type of sound, and the sound-box magnifies the sound and makes it audible. Recording is the opposite process: the sound controls the needle and makes it cut a groove in a smooth disk revolving under it. Have you ever heard your own voice—on a gramophone, I mean?'

'Oh, no!'

'In London you can go to a shop and pay a few annas, and they make a tiny little record of whatever you say; it is small enough to go in an envelope, so you can record a message to him by post.'

Mr. Gupta walked into another small room at the back, also crowded with instruments, and spoke to someone there.

'There happens to be a small unused bit left on an old record,' he said, returning, 'and the studio is free just now. Come.'

He led the way back to room No. 4 and seated Hitindra in front of the microphone.

'Now,' he said, 'begin talking; just say anything you like, for two minutes.'

Hitindra at once felt nervous, and could hardly think of anything to say. He gave a cough, and then another, and began repeating a few things he remembered from the Professor's talk, beginning with something about sun-spots. But it was difficult to keep on talking for two minutes.

'All right,' said Mr. Gupta, 'let's go back to the control room.'

There was now a kind of very large record lying on the machine, and the official in charge of it lowered the needle on to it. To Hitindra's surprise, the needle began moving outwards from the centre, instead of inwards. A moment later two loud coughs sounded, and a voice began to speak. Hitindra recognised the words he had just spoken, but he could not recognise the voice at all.

Professor Nizami laughed at his astonished face.

'That is exactly how your voice sounds to others,' he said, 'but it sounds different to you. Very few people can recognise their own voices on a record. Mr. Gupta, may we have a look into the gramophone room ?'

'Yes, it isn't on the air now.'

They went into another room, where there were big cupboards full of records, and a horse-shoe-shaped desk with two gramophone disks fixed on it, one on each side.

'The operator sits here, between the two,' explained Mr. Gupta, 'so that if he is playing a long piece of music, he can have the next record ready to start on the second machine, as soon as the record on the first ends.'

'What is this little dial in the desk ?' asked Hitindra.

'We use that when we want to start a record in the middle, at a particular place. We play the record up to the point where we want to start, and set this needle at that position.' He put on a record and played a little of it. Until he pressed a switch, and a loudspeaker set in the wall began to work, nothing could be heard but a thin scratching.

'That dial is useful when we are giving plays,' he went on, leading his visitors into a big studio across the corridor. 'Between the scenes we usually play a little music, which is carefully chosen beforehand.'

'But how does the man in the gramophone room know when to start ?'

'He is listening to the play through his earphones, and he has a copy of the play in front of him. Besides music, most of the noises you hear in a play are put in by him. We have special records of the sound of guns firing, soldiers marching, crowds cheering, and so on, the gramophone man has to be careful to put them in at exactly the right moment.'

'What is this ?' asked Hitindra, pointing to a thin sheet of metal, six feet high, hanging from a wooden frame.

'This is to imitate the noise of thunder. Just touch it.'

Hitindra did so, and the loud rolling noise made him jump.

'The actors stand round those microphones,' said Mr. Gupta, pointing to two microphones on thin stems as high as a man's face, in the middle of the room. 'Andin the little room over there, the sound-control man sits at the desk listening through earphones and turning those knobs. He makes the voices louder or softer, and when there is music at the same time he has to make sure that it is loud enough to be heard, but not loud enough to drown the voices.'

Next they peeped into the music-room, from which a programme was being broadcast just then. (Each studio door had a small round window in it.) A famous singer was sitting on the floor at one side, with a ring of the station musicians playing their instruments round him. An official was sitting in front of the singer, watching the clock. Presently he gave a signal with his hand, and half a minute later the music stopped.

'Now we are relaying a programme from Delhi,' said Mr. Gupta. 'Well, I hope you will be more interested in listening to the radio, now you have seen how the Station works!'

'Oh, yes!' said Hitindra, 'Thank you for showing me round!

As he and the Professor walked home together, Hitindra said—

'In your talk you were saying something about wireless waves, weren't you? What I don't understand is how they go round the world, for instance from London to Lahore. Why don't they go away from the earth, in straight lines?'

'Luckily for us, about seventy miles above the earth there is a belt of electrified gases, through which long wireless waves can't pass; and about twice as high up is another belt, which stops most short waves. The waves are reflected back to the earth, and from the earth they bounce up again to those layers—and so on. A message sent a long way round the earth may have to bounce up into the sky and down to the earth six or eight times. It is not coming to your receiver in a straight line from the transmitter.'

'But what is the cause of those electrified gases?'

'Up there the air, which is a mixture of gases, is very thin, and it is being excited all day long by the enormous quantities of energy pouring into it from the sun:—energy in the form of light, heat, and all kinds of electric and other waves. The sun is more than a hundred thousand times as big as the earth. It is a kind of huge atom bomb, exploding all the time; only our atom bombs weigh only a few pounds, while the sun pours out every second as much energy as an atom bomb weighing three or four million tons. Luckily only a tiny fraction of that energy strikes the earth.'

'How can you tell what is happening seventy miles away from the ground?'

'Scientists have many instruments for the purpose. Of course, we can't fly so high because the air is too thin. Even a balloon will burst at about twenty miles up. The Department in America for studying the weather sends up balloons every day to a height of nearly twenty miles. They carry automatic instruments to register the weather conditions up there, and then the balloons are brought down again and the instruments examined.'

'Have we a department like that in India?'

'Yes, all countries have one, and their wireless stations every day announce what weather is to be expected the next day. There are thousands of people all over the world studying hour by hour the winds, the air-pressure, and all the factors which govern the weather. Everybody wants to know what tomorrow's weather will be like ; especially farmers and sailors and airmen.'

'And what was that you said in your talk about sun-spots ? '

'The sun-spots are gigantic storms of electrical energy, raging on the sun. They move slowly across it, in a regular period of time, and they disturb weather conditions on the earth. It is an old theory that the bad harvests we have every few years are due to the sun-spots. Bad harvests mean bad trade, bad trade means unemployment. So if the theory is true, you see how important those dark spots on the sun are ! '

They reached home, and Hitindra remembered that he was very hungry, so he ran to find some food, and then sat down to listen to the radio, thinking about the studios he had just visited.

IX. HOW FILMS ARE MADE

Romesh had come back to college after three days' leave, and as he had no lectures, he thought the best way to begin the day would be to have a swim.

When he got near the open-air swimming pool, he was surprised to notice quite a crowd of strangers standing round at one end, and to hear a loud voice shouting orders in an angry tone. On the far side, where the trees were, a big motor-van was parked.

The first idea that struck him was that there must have been an accident, and that the van was an ambulance. But he had never heard doctors shouting like this. Then he noticed, standing near the group, his friend Rashid, a first year student like himself.

Romesh went up to Rashid on tip-toe, and whispered to him.

'Oh, is that you!' exclaimed Rashid, turning round. 'What are you whispering for?'

'I don't know—I say, what has happened?'

'What *is* happening, you mean! Why, these men have come to make a scene of a film here. Don't you see the van over there?'

Romesh looked again, and from where he was now, he could see that the van was marked in big letters with the name of a well-known film company.

'So that's what it is!' he said, 'I thought at first someone must have got drowned. But why have they come *here* to make the scene? Do you know anything about them?'

'I know *all* about them. You see the man over there?' He pointed towards a big camera mounted on wheels. 'That is Mr. Ghulam Ali, who is an old friend of our family. He works for this company.'

'Well, what do they want our pool for? I came to have a swim.'

'You can have a swim soon. They have nearly finished. The point is, in the story of this film the hero has to dive into a stream to try and find a bag of diamonds that has fallen into it. They have not got a river in their studio, of course, so they have borrowed our pool. Come to the edge and look.'

'Rashid!' cried Romesh in alarm, as he looked down into the water—'there's an alligator floating in the pool!'

'Don't worry, it is a dead one.'

'Dead!'

'Yes; caught and stuffed specially for this film.'

'But it's moving!'

'It's fixed on a long wire—don't you see that man on the bank pulling the end of a wire? You can scarcely see the wire in the water, so it will look on the screen as if the alligator was alive.'

'Yes, but what do they *want* an alligator for?'

'It has to attack the hero and prevent him from finding the diamonds.'

Romesh looked round the pool, and noticed that a brick wall, rising above the surface, had been built across one corner, keeping the water out. A man was bending down in this dry enclosure, doing something with another big camera.

'They emptied the pool yesterday and built that wall,' said Rashid, seeing what his friend was looking at. 'The wall has a glass window in it, and that camera will be able to photograph the hero and the alligator underneath the water.'

'Who is the big man on that chair who keeps shouting all the time?' enquired Romesh.

'He is the Director. Everybody including the actors has to do exactly what he says.'

'Where are the actors?'

'They are getting ready in the tents over there. Only two of them are needed for these scenes, the hero and the heroine. Look! they are coming out. Let's go closer.'

Romesh was afraid the Director might begin shouting at them, but his friend seemed quite confident, so they joined a group of men who came and stood round the hero as he came to the bank. He was a handsome young man wearing only a loincloth, but his face looked very strange; it was thickly covered with paint and powder, and there was some black stuff on his eyebrows.

Two men brought up a tall wooden stand, with a horizontal bar jutting out from its top; hanging from the end of this was a metal object, which was just above the actor's head.

'That's the microphone,' said Rashid. 'It will catch his voice and send it along the wire stretched across the ground to that van, where the recording machines are.'

'What are those other men doing?' asked Romesh, pointing to a group who were carrying upright sheets of shiny metal supported by wooden frames.

'Those things are arranged so as to catch the sun and reflect as much light as possible on to the actors. When they are taking scenes, indoors, they use very powerful electric lamps instead.'

The Director's chair was carried over to where the actor stood ready, and he sat down and gave another long set of orders at the top of his voice. Then the actor went back about twenty yards, turned round, and came rushing up to the bank as if in great excitement. Just as he came under the microphone, he waved his arm and called out: 'I'll find those diamonds for you!'

Mr. Ghulam Ali came up to the Director, they talked together for a minute, and then said something to the actor, who walked away again and did the same as before.

Again the Director talked to those standing beside him, and again the actor came rushing up. This happened eight times, until Romesh was getting tired of it.

'They have to practise each bit very carefully before they photograph it.' Rashid explained. 'The men in the van are listening over the wire to make sure that the microphone is in the right position; the camera-man has to watch through his lenses and make sure that the focus is right; and the Director has to make sure that the actor's voice and face are just as they should be. Ah! Now they will begin 'shooting'!'

The Director had suddenly shouted 'Silence!' and everyone else began shouting 'Silence!' Then there was a hush, and the camera started working with a whirring noise, as the camera-man turned the handle. A man held up in front of it for a moment a slate with a number chalked on it. The actor rushed up, called out his six words, and raised his arms as if he was about to dive into the pool. Then the man with the slate held it up again, the camera stopped, and everyone began talking.

'Is that all!' said Romesh, disappointed. 'I thought he was really going to dive in it and have a fight with the alligator!'

'All that will come later,' said Rashid. 'First they will 'shoot' one other bit where the hero has to wear the same dress. If he dived in now, all the paint would be washed off his face, and he would have to waste half an hour putting it on again. The Director always picks out all the bits of the film he has to make where the same actors, same costumes, same settings, are to appear. He 'shoots' all those bits one after the other. Then, at the end, he fits all the pieces together in the right order.'

'So that is why they had the slate with the number on it?'

'Yes.'

'Whom was the hero supposed to be calling out to in the last bit?'

'The heroine; she is in a small boat on the river. She was photographed separately before you came.'

There was now a great deal more shouting and running about; it was half an hour before the hero at last dived into the pool. Both cameras were working, and the man in charge of the alligator made it 'swim' to and fro, by jerking his wire, as if it were alive.

When it was over, Mr. Ghulam Ali walked across to the two boys.

'We have done a good morning's work,' he said with satisfaction. 'We have taken four shots, with a total length of five and a half minutes.'

'Is that all!' said Romesh. 'Do you call that a good morning's work?'

'Certainly. Very often we spend a whole day rehearsing and arranging things, without taking any 'shots' at all. A full-length film isn't an easy thing to make. Well, we are going back to the studio now. Would you like to come along in my car and see the place?'

'Oh, yes!' replied Romesh and Rashid together. Their friend led them to his car, and a minute later they were on their way.

They looked round the studio for a long time. Scattered through the buildings were half a dozen sets of scenery, made of painted wood and cardboard. One represented the verandah of a bungalow, one was a sitting-room, and so on. These 'sets' were all to be used for different scenes of the film. They looked so real and solid, that Romesh tried to lean against one door; but it was made of such thin ply-wood that it collapsed, and he fell down.

One building, with a dozen rooms, was filled with costumes and ornaments. There were rows and rows of big cupboards, each holding fine dresses of a particular kind, such as dresses belonging to a certain period of Indian history. Other cupboards contained heaps of necklaces, bangles and ear-rings, or suits of armour, spears and swords.

'You see now one of the things that make films so expensive,' Mr. Ghulam Ali remarked. 'The dresses here have cost us thousands and thousands of rupees. Then there are so many actors to be paid; our bill for electricity is very heavy ; and the machines we use, which are bought from abroad, are very expensive.'

'How much does it cost to make one film ?' asked Romesh.

'It varies very much. Sometimes only half a lakh ; sometimes several lakhs. In America they may spend even a crore of rupees on one film.'

Mr. Ghulam Ali led them across the compound to another building, where there was a big room full of machines and instruments.

'Here is where the really important work is done,' he said. 'Look ; here is the film as it comes from the camera.' He picked up a spool, with a long narrow strip of celluloid rolled round it, and unwound one end. 'Hold this up against the light.'

The two friends did so, and saw that the reel was covered with tiny little photographs separated by dotted lines.

'When the film is in the projector, of course,' said their guide, 'the strip is drawn so rapidly across the beam of light, that the pictures don't appear separately on the screen ; they melt into each other. Ten photographs of a man, holding his arm a little higher each time, look on the screen like a man lifting his arm in a continuous movement.'

'Why did you say the important work was done in this room ?' enquired Rashid.

'This is where the cutters work. They are experts who look at the film when it has all come from the Director ; they put the film in this instrument and look through the eyepiece, and decide how much to leave out.'

'Why should any part be left out ?'

'We always photograph far more than we put in the film in its final form. The cutters chop the reels up, decide on the best order of the scenes, cut out what is unnecessary, and then have all the pieces stuck together to form a single reel.'

'And then it is ready at last ?'

'Yes, then it is put on the screen in our own private cinema hall here, and the producer and his advisers watch and give their final criticism.'

'Why don't we have colour films in India ?'

'We shall soon. They require a special camera ; they are much more expensive to make.'

'And what about television ?' said Rashid.

'That also will come soon in India,' replied Mr. Ghulam Ali. 'People will soon have small television sets at home, as they have ordinary radio sets now ; and besides, there will be special cinemas where plays will be shown on a big screen, while the performers act and speak in the radio station far away.'

'That seems very wonderful !' said Romesh. 'How does television work ?'

'Well, to put it very simply : a very strong lamp shines through a lens on to the face, or whatever it is, that is to be televised. Between this object and the lens is hung a round metal plate, with a series of small holes in it ; the plate spins round rapidly, and the light passes through the holes on to the object. The light is reflected, in brighter or darker patches, on to a photo-cell : that is, a device which controls an electric current in accordance with the amount of light falling on it. You understand ? '

Romesh and Rashid looked at each other doubtfully.

' The electric current is transformed into wireless waves,' Mr. Ghulam Ali went on. ' At the end, everything happens the other way about : wireless waves, electric current, photo-cell, light. However, for a play we need sound as well as light. At first, the words were broadcast on separate wireless waves ; but now, by a new invention, the light and sound can be transmitted on the same waves. This will make television cheaper.'

' We are both Arts students,' said Rashid ; ' this scientific talk is difficult for us ! '

' Well, come to our rest-rooms and let me give you some lemonade to cool your brains ! '

They sat down in a fine big dining-room, and began drinking.

' You may be surprised to hear,' remarked Mr. Ghulam Ali, ' that in a sound-film, even the sound is photographed. Sound consists of waves in matter ; it travels through air at about 1000 feet per second, through water at

5000, and through some things, like rock, much faster still. Whether a note is high or low, depends on the number of waves, or vibrations, per second. The faster you make a violin string vibrate, the higher is the note it gives. You know that much, I suppose ? '

'Yes,' replied Rashid.

'Of course,' added Romesh, though he was not quite sure whether he had known it before or not.

'With a microphone, we transform the sound of the actor's voice into electric waves running along a wire. Then, with a photo-cell, we transform the electric current into light, and actually photograph it. In the cinema the machine turns the light back into sound. By this method we get the picture on the screen, and the sound from the loud speaker, fitted exactly together.'

When Romesh at last got back to the pool to have his swim, he was wondering whether to begin learning science and become a cinema expert.

NOTES AND EXERCISES

Chapter I

GLOSSARY

A refrigerator : An apparatus by means of which any liquid or solid food is kept cool or cold.

A purring noise : A vibrating sound coming out of an electric motor or some other apparatus like the megaphone or large speaking trumpet.

Hydro-electricity : Electricity generated by using water as the power to work turbines.

Middle Ages : The period of history between 1000 and 1400 A.D.

Tramways : A system of cars for passengers moved by electric power along lines of rails.

The Persian Wheel : Is a common device for drawing water from a well, used in India. It is worked by a bullock, a camel or a buffalo. The Urdu word for it is '*reht*'.

EXERCISES

I. Write sentences using the following :---

As a matter of fact, all the time, as if, to give up, by the way, to fall back to, to play a great part, to be better off, after all, to and fro, to think of, in the same way, to carry on, at length, before long, worth living.

II. Complete the following sentences by using the very words of the book.

(*i*) It makes me thirsty------.

(*ii*) As he did so, an electric bulb inside------.

(*iii*) You are really living------.

(*iv*) You stand on the lower step and------.

(*v*) Sky-scrapers seem to be -----.

III. Answer the following questions :---

(*i*) What special comforts did Gopal Krishan find at the house of his uncle ?

(*ii*) What happened when the current failed ?

(*iii*) What would a city life be without electricity ?

(*iv*) How do you know that our brains are giving out electrical currents ?

(*v*) What special use can we make of the streams and waterfalls of the Himalayas ?

IV. Describe briefly in some ten or twelve lines each :---

(*i*) A Refrigerator.
(*ii*) Underground Railways.
(*iii*) A Lift.
(*iv*) A Moving Staircase.
(*v*) Imagine yourself to be Gopal Krishan and write a letter home, telling your father all that you have learned about electricity.

Chapter II

GLOSSARY

Conjuring tricks : Feats of jugglery.
Motor tractors : Motor ploughs.
Good-humouredly : In a happy mood.

EXERCISES

I. Frame sentences using the following :---

To go round, instead of, of course, after all, out of breath, to start off, at the sight of, to go to bed, to sing oneself hoarse, to shake hands, to die of, a great deal.

II. Word Study :

Learn the spellings of the following words and give their meanings in your mother-tongue :---

Enthusiasm, conjuring tricks, experimental stations, ignorance, crossing, nitrogen, sulphur, starch, vitamins, blushed, primitive, scribbling, emigrate, million, starvation, adopt, average, production, foreign, co-operative, instance, pests, experts, horrible, punctures, expensive, miracles, favourite, decay, bulk.

III. Give antonyms for the following :---

Emigrate, production, ignorance, horrible, fine, go.

IV. Write about fifteen lines on Potato. Can potato avert a famine ?

V. Write ten lines on Russian methods of agriculture.

VI. Answer the following questions :---

(*i*) What kinds of experiments in agriculture are being made at places like Simla and Lyallpur ?

(*ii*) Why is potato a very important thing as food ?

(*iii*) How is cultivation carried on in Russia ?

(*iv*) How can we grow vegetables without any lands ?

(*v*) How do men of the Department of Agriculture draw farmers towards them instead of talking to them directly about new ideas on Agriculture ?

Chapter III

GLOSSARY

Technology : The Science of Industrial Arts.

Massachussets : An important state and town of the U.S.A.

Laboratory : A place used for scientific experiments, especially in Chemistry or for manufacture of chemicals.

Observatory : A building fitted with instruments for the study of the movements of heavenly bodies.

Out of date : Which serves no good purpose, old-fashioned, clumsy.

Bobbing up and down : Moving up and down.

Infra-red light : Invisible rays beyond the red end of the spectrum.

Rocket : A paper or metal case, full of powder, used in fireworks. It is cylindrical in form and has a long bamboo strip fastened to it. It is closed from above, and when ignited through a hole at the lower end, it can be sent up into the air to a certain height.

EXERCISES

I. Frame sentences using the following :---

Out of date, to take care of, at least, up and down, to wander about, to wipe out, a lot of, to look forward to, to lead to, to work up, to consist of.

II. Put into the indirect form of narration the passage beginning with ' you can go... ..if you are lucky.' (Page 29)

III. With the help of your book give th e definitions of the following after the manner of the one given below :---

A microscope is an instrument for making small things look a hundred times bigger.

A Microscope, A Telephone, A Radio, A Jet-propelled Plane, An Atom Bomb.

IV. Answer the following questions briefly :----

(*i*) What does a hair look like when seen through a microscope ?

(*ii*) What kind of spectacles are expected to be made in a few years ?

(*iii*) How do radio waves help us in finding that some mountains are near ?

(*iv*) What kind of a plane can take us to the moon ?

(*v*) How many atoms make up a human body ?

V. Express in your own language the meaning of the paragraph :---

(a) beginning with "You see how very small an atom is." (Page 31.)

(*b*) What are the advantages and disadvantages of Atomic Energy ?

Chapter IV

GLOSSARY

A telephone receiver : The ear-piece.

Geologist : An expert in the science of the Earth's crust, its strata and their relations.

Short or long bursts : More properly called *dots* and *bars*, by means of which letters are signalled.

The Ticker : A small box-like machine with a slot, through which a white ribbon comes out. There are news printed on the ribbon.

Radio Telegraphy : Messages sent through radio.

EXERCISES

I. Construct sentences using the following expressions :---

Important bit of news, lost their lives, look for, go on a voyage, on an average, a couple of hours, to get in touch with, ring up the steamship, bound for, a telephone call, hand a thing on, out of order, had better run, rough and ready, from end to end of the country.

II. Fill in the blanks with right prepositions :---

(*i*) He stood-----hours-----the Marine Drive, staring-----the sea.

(*ii*) The man Jha once went-----a scientific voyage.

(*iii*) "Jha lives-----Bhatinda," went-----the Sub-Editor.

(*iv*) I send a dozen telegrams, every day-----an average.

(*v*) I have three men running -----and-----Bombay trying to find him.

(*vi*) He hurried-----the corridor-----another office.

(*vii*) " Anything new-----the South Pole ? " enquired Mr. Puri.

(*viii*) Sikandar was more interested ------the Ticker than -----the news.

(*ix*) Sir L. K. left this morning-----8 a.m.-------the *S.S. Lion*, bound-----South Africa.

III. Express the meaning of the following sentences in your own mother tongue :---

(*a*) As the school was on holiday, he took the boy with him.

(*b*) Half a dozen typists were typing away as if their lives depended on it.

(*c*) The machine prints the messages all day as they arrive, on the tape ; it works like a typewriter.

(*d*) " Why must they let it go out of order today of all days ? " He walked up and down the room frowning, and then stopped at the desk and banged his fist on it.

IV. Write a brief note on how important news are collected by the editors of newspapers through their agents.

V. (*a*) Give the words with opposite meaning (antonyms) of the following :---

right, busy, famous, forget, war, complicated, enter, morning.

(*b*) Use the word " right " in at least four different ways.

(*c*) What difference does it make when we add ' the ' to the following :---

Chinese, English, French, Greek, Dutch ?

Chapter V

EXERCISES

I. Practise the following usages :---

To fall off, in his turn, at full speed, to set on fire, to spin round and round, to go round and round, out of sight, to work out, to spread out, to pull oneself up, to line up.

II. (*a*) Describe the following (Put in the names of different parts of a tank and aeroplane).

(1) A ride in a tank. (2) A ride in an aeroplane.

(*b*) How do gunners find out the enemy in sea and on land ?

III. Make nouns from :---

Do, excite, explode, calculate, complicated, think, go.

IV. Analyse the following sentences into clauses naming the kind and function of each :

(1) If you wait, you will be dead long before you see him.

(2) At first he could hardly see anything ; there were only a few cracks through which light came.

V. Translate into a modern Indian language the paragraph (It was soon..............believed it). (Page 48)

VI. (*a*) Express the following talk in the indirect form of speech :---

" Oh, Uncle ! " cried Anup Singh, " we've been watching all the time : uncle, can you give me a ride inside one of the tanks ? "

" I might be able to, if your teacher will let you come. But I can tell you that you won't enjoy it, my boy."

(*b*) Change the sentences given below into simple sentences :---

(*i*) There was a sudden lurch and the tank began to move.

(**Hint**.---*The tank began to move after a sudden lurch.*)

(*ii*) A big tank is so heavy that it cannot be turned by a steering wheel. (**Hint**.---Use the adverb " too.")

(*iii*) At last they reached the big maidan *where the parade was going to be held.* (**Hint**.---Reduce it to a phrase such as the place of the parade.)

(*iv*) The steel belt runs over this set of cogwheels here, just as the chain of a bicycle goes round and round. (**Hint**.---Use the word ' like '.)

VII. Make up a list of words, bearing on the work of a soldier and parts of aeroplanes and tanks.

Chapter VI

GLOSSARY

The stethoscope : An instrument to listen to the movements of the heart and lungs with.

X-rays : A form of radiation which penetrates many substances, through which ordinary waves cannot pass.

A leech : A kind of blood-sucking worm, which lives in water.

Pasteur : Full name Louis Pasteur. He was a French chemist. He was born at Dole, December 27, 1822. He was professor of Chemistry at Sorbonne. He discovered methods for the prevention of diseases in vines, studied tqe silk-worm disease and prepared vaccines for rabies and other diseases. Rabies means madness caused by dog bite.

Epidemics : Are diseases prevailing among people at a time.

Moss : Small plants growing in bogs, or on the surface of ground, trees and stones.

Transfuse : transfer blood from the veins of one person or animal to those of other persons.

EXERCISES

I. Practise the following usages :---
get something into one's head, to feel nervous, it was all over, to seal up every door, the majority of, deadly to, to make sure, die of, keep it alive, there was nothing wrong with, make it grow, heals up.

II. Fill in the blanks with prepositions :---

(*i*) As they had to wait---some time, he took Madan---the building.

(*ii*) This is all very different---the way sick people used to be treated---old days.

(*iii*) Our blood is the most valuable thing we have to restore us---health.

(*iv*) The electric wire prevents the veins that are cut---bleeding.

(*v*) Microbes float---the air, or live---water, or are carried about---animals---their skins.

(*vi*) He injects something---the person's blood.

(*vii*) We can't stop people ---dying---old age.

(*viii*) What do you think---exchanging eyes ?

III. (a) Form verbs from :
food, blood, loss, weak, danger.

(*b*) Form nouns from :
die, discover, inject, transfuse, operate.

(*c*) Form adjectives from :
nerve, pain, value, danger, surgeon.

IV. Answer the following questions briefly :---

(*i*) How does a doctor examine a patient ?

(*ii*) How is an x-ray photograph taken ?

(*iii*) What was the chief remedy used by doctors in the 18th century ?

(*iv*) What is the special advantage of chloroform ?

(v) What happens when an injection is given ?

V. Write to some relative in the country telling him what progress the science of medicine has made in the recent years. Make special mention of the practice of injection, transfusion of blood, and exchange of organs.

Chapter VII

GLOSSARY

Drill into the earth : Boring a hole into the earth y means of a boring tool or machine.

A Scoop :---A small bucket attached to the boring pipe.

Cancer : A very troublesome swelling in some part of the body, that spreads very fast.

Smelting : The act of melting an ore to extract metal.

A flaming furnace : A fire-place for subjecting metals to great heat.

A shaft : A hole serving as access to a mine.

Julius Cæsar : The name of a Roman emperor who ed over England.

Criss-Cross : Crossing of lines.

EXERCISES

I. Practise the following usages :---

To set off, any longer, to drill into the earth, to go in for, to work at, make up one's mind, to last for a long time, to dream.

II. (*a*) Construct sentences using the following words as verbs :---

Ship, hammer, answer, chain, oil, stone.

(*b*) Construct sentences using the following words in as many ways as you can :---

mean, plain, light, like, want, good.

III. Complete the following sentences with the help of the book :

(i) Oil is being used all over the world......................

(ii) Uranium is the most dangerous stuff in the world because..............................

(iii) At the end of our work we should be much poorer than.................................

(iv) One part of aluminium with nine parts of copper gives..............................

(v) When two metals are melted together to form an alloy.................

(vi) In Russia, for instance, one of the Ural mountains is an almost solid block of iron.................

IV. Answer the following questions briefly :---

(i) What is a meteor ?

(ii) In what *sequence* were metals found ?

(iii) How is steel formed ?

(iv) Why is an alloy harder than the metals of which it is made up ?

(v) How do engineers guess where iron or coal is likely to be found ?

V. Write a short essay on the distribution of important minerals in the world. In which parts of the world are they found ?

Chapter VIII

GLOSSARY

Chromium-plated metal : A metal covered with a flat thin sheet of chromium which is a precious metal).

Sound-proof : Something through which sound cannot pass.

Earphone : Telephone receiver fastened with a belt to the ear.

Transmitter : The instrument by which a message is sent.

Sound control : The power of directing sounds properly.

Automatic : Working of itself, self-working.

Sun spots : Dark patches sometimes observed on the sun's surface.

EXERCISES

I. Practise the following usages :---

to slow down, sound-proof, switch on, make oneself comfortable, with fifteen seconds to spare, to be on the watch, up to date, a gramophone disk, in front of, to relay a programme, to give a signal, luckily for us, all day long, to make sure, to drown other voices.

II. Study the words *ear*, *proof*, *control*, *and sound* with the help of a good dictionary, and give the meaning of the following expressions :---

(*i*) an ear for music, give ear to, be all ears, within ear-shot.

(*ii*) bomb-proof, water-proof, fire-proof, bullet-proof, sound-proof, weather-proof, rain-proof, burglar-proof.

(*iii*) Paper control, birth control, to have control over himself.

(*iv*) Use sound as an adjective, a verb, a noun, and an adverb.

III. Fill in the blanks in the following :---

(*i*) Hitindra was-----of listening-----the radio.

(*ii*) They went in and-----a corridor to where two officials -----sitting-----a desk.

(*iii*) This is-----talk-----am going to read.

(*iv*) Just make-------comfortable------the sofa------- there.

(*v*) As soon-----you hear a-----, and that glass tube-----the door, this studio will be-----

(*vi*) Mr. Gupta will let you-----a look.

(*vii*) So the-----goes out-----this room all-----the Punjab.

(*viii*) Nine------clock-------the evening-------London -----about 2-30 a.m. here, when every one is----.

IV. Relate briefly how Professor Nizami gave a talk on the radio.

V. Answer the following questions briefly :---

(*i*) How are the walls of a radio station room made sound-proof ?

(*ii*) What kind of practice is given to a talker before he broadcasts his speech ?

(*iii*) How are short messages recorded in London ?

(*vi*) What is the Sound Control-man's business ?

(*v*) How does the operator work in the gramophone room ?

Chapter IX

GLOSSARY

A Van : A large usually covered vehicle especially for carrying goods.

An ambulance : A moving hospital following an army.

On tip-toe : Walking on toes for quietness.

An alligator : A reptile of the crocodile family.

A microphone : A device for making faint sound louder.

Costumes : Suits of clothes representing different styles.

Settings : Scenery and costumes of a play.

A full length film : A complete film.

A spool : a reel.

Television : The seeing of distant events or objects. The process by which this is effected.

EXERCISES

I. Practise the following usages :---

To have a swim, an open-air swimming pool, mounted on wheels, recording machines, to catch the sun, in great excitement, with a whirring noise, as if it were alive, a good morning's work, a full length film, bill for electricity, final criticism.

II. Suggest suitable verbs for the sentences given below :---

(*i*) A big motor-car is---(brought to a stop).

(*ii*) Now they will---the film (bring a scene on the film by means of a camera).

(*iii*) Very often we spend a whole day---(repeating the words that we have to utter in an act).

(*iv*) The door was made of such thin plywood that it---(tumbled down).

(*v*) The faster you make a violin string---(move to and fro) the higher is the note it gives.

III. (*a*) How would you put the following talk in the words of Rashid ?

" Rashid," cried Romesh in alarm, as he looked down into the water, " there's an alligator floating in the pool ! "

" Don't worry, it is a dead one. "

" Dead ! "

" Yes ; caught and stuffed specially for this film. "

" But it's moving ! "

" It's fixed on a long wire---don't you see that man on the bank pulling the end of a wire ? "

(Begin thus : As Romesh looked down into the water, he pointed out to me that an alligator was etc. I asked him not to worry and assured him that it was a dead one, etc.

Complete the incolmpete sentences before changing them into indirect.)

(*b*) Give a clause analysis of the following :---

(*i*) Who is the big man on that chair, who keeps shouting all the time ? " enquired Romesh.

NOTE. " Romesh enquired " is the Principal Clause.

(*ii*) If he dived in now, all the paint would be washed off his face and he would have to waste half an hour putting it on again.

IV. Mention briefly in two short paragraphs all that Romesh saw in the studio and the process section, namely, the big building where the spools were developed and joined together.

V. Answer the following questions :---

(*i*) How is shooting done in the open air ?

(*ii*) What is a microphone, and how is it connected with the recording machine ?

(*iii*) How do cutters work ? Why do they leave out some parts of the film ?

(*iv*) How do pictures melt into one another, so as to look like a motion picture ?

(*v*) What special features will be added to our radio set, by the addition of television apparatus ?

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